MECHANICAL ENGINEERING

January 1933

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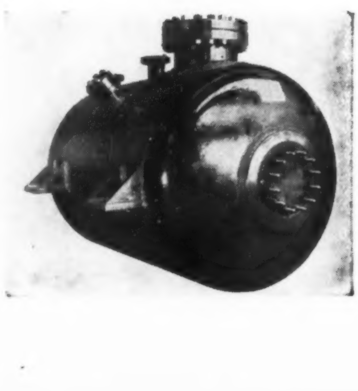

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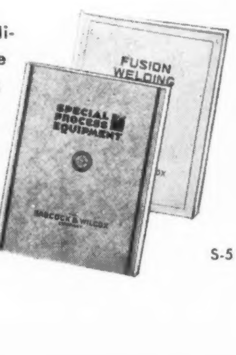

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MECHANICAL ENGINEERING

Published by The American Society of Mechanical Engineers

VOLUME 55 NUMBER 1

Contents for January, 1933

Published monthly by The American Society of Mechanical Engineers. Publication office at 20th and Northampton Streets, Easton, Pa. Editorial and Advertising departments at the headquarters of the Society, 29 West Thirty-Ninth Street, New York, N. Y. Cable address, "Dynamic," New York. Price 60 cents a copy, $5.00 a year; to members and affiliates, 50 cents a copy, $4.00 a year. Postage to Canada, 75 cents additional, to foreign countries, $1.50 additional. Changes of address must be received at Society headquarters two weeks before they are to be effective on the mailing list. Please send old as well as new address. . . . By-Law: The Society shall not be responsible for statements or opinions advanced in papers or . . . printed in its publications (B2, Par. 3). . . . Entered as second-class matter at the Post Office at Easton, Pa., under the Act of March 3, 1879. . . . Acceptance for mailing at special rate of postage provided for in section 1103, Act of October 3, 1917, authorized on January 17, 1921. . . .

UNIFYING *the* ENGINEERING PROFESSION

Presidential Address at A.S.M.E. Annual Meeting

By CONRAD N. LAUER[1]

MY ILLUSTRIOUS predecessor, Robert Henry Thurston, first President of The American Society of Mechanical Engineers, delivered an address before this Society in November, 1880, in which he set up for all who were to follow him in this office an obligation to deliver a presidential address and a standard of excellence for that address that it is difficult to attain. Those who, in recent years, have read Dr. Thurston's words express amazement at his wide knowledge of contemporary engineering, his prophetic vision of future developments, and his clear understanding of the relations of engineers to their profession and of their profession to questions of public interest.

The concluding section of Dr. Thurston's address is entitled "The Ethics of Cooperation." He had affirmed that in the work of the engineering society there was a need for men of the world and men of science, "observers, discoverers, and inventors, explorers in all fields of research, students of nature's facts, and codifiers of nature's laws and teachers of all applied sciences, as well as workers in field, in workshop, and in office." He added, "We shall find that the promotion of mutual welfare is consistent with the most perfect system of mutual cooperation and mutual aid in all the truest and highest aims of life." Tonight I wish to direct your attention to some cooperative efforts that affect not only our professional welfare but the public interest, and to indicate the desirability of finding a simple and effective way of coordinating them.

Obviously an effective profession must be a united one, and for this reason this Society may well concern itself with the organization of the engineering profession as a whole. To that end let me review briefly the steps that have been taken over a period of years by which united action by the profession has been secured, and let me offer some suggestions as to future steps for the unification of society organization.

These projects illustrate convincingly the benefits of cooperation in accordance with the unwritten principles which have always actuated this Society in such relationships: First, unselfish cooperation with other related societies; second, planning actively for the future so that development may not be haphazard; third, giving the most effective service to members of the engineering profession; and fourth, inspiring the engineering profession to render the most valuable service that it can to the public.

THE DEVELOPMENT OF THE SPIRIT OF COOPERATION IN ENGINEERING SOCIETIES

The earliest engineering societies were formed, as was our own, by groups of individuals as agencies for the self-improvement of members through the presentation and publication of papers, the development of the professional spirit, and the pooling of individual library resources. In addition these societies provided certain standards of attainment in engineering as expressed in the qualifications set up for various grades of membership. These were worthy objectives in days when the engineering profession was young and its members were poorly organized. They will always remain the essential objectives of such organizations. They satisfied our needs as specialists in engineering and absorbed practically all of the activities of engineering societies until the turn of the century, when the impact of engineering was making itself felt in the social and economic changes in civilization. At that time engineers were becoming conscious of their growing importance in the changing life of the world, and sought by working together with other men practicing in the same fields to give direction and effectiveness to their professional work. Engineering had emerged as an important cultural factor that transcends the narrow limits within which its numerous branches are traditionally confined. An insistent urge for a united profession as a means of increasing the effectiveness and prestige of the individual engineer in private practice and of professional bodies in the public service, with the same recognition of the profession by the public generally that is accorded to older professions, had made itself known in various movements looking toward greater unity of objectives and actions. This seemed in many ways to be counteracting the centrifugal forces that had been at work for some time and had resulted in a galaxy of individual societies of specialists, and to lead logically to the coalescence of these numerous groups into a single national engineering society. Before discussing the desirability of such a coalescence, let me review briefly some of the major activities that have been the result of cooperation for the common good.

SOME EXAMPLES OF ENGINEERING-SOCIETY COOPERATION

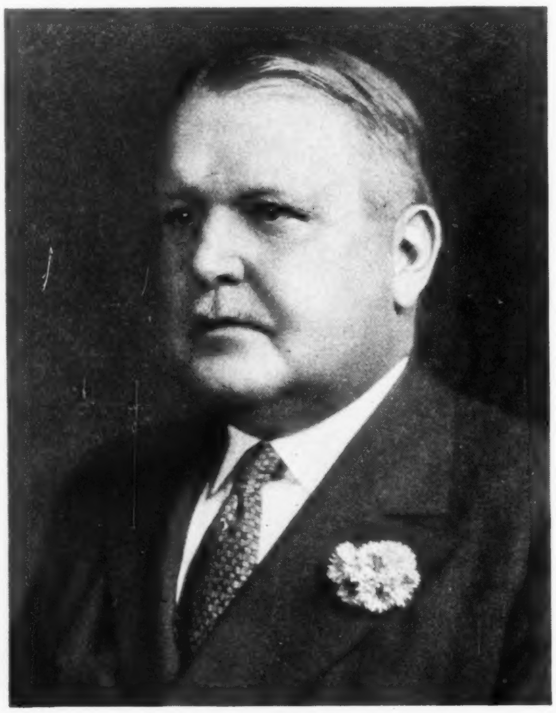
An early evidence of this desire for team work was the

[1] President, A.S.M.E.

Presidential Address delivered at the Annual Meeting, New York, N. Y., December 5 to 9, 1932, of The American Society of Mechanical Engineers.

foundation, in 1902, of the John Fritz Medal for the recognition of leaders in engineering. Later, Andrew Carnegie, a man of rare and far-seeing vision, provided an exceptional opportunity for cooperation by his gift of the Engineering Societies Building in New York, the present home of many of the major professional engineering organizations, where the library facilities of the four Founder Societies are consolidated in one of the best and most widely used engineering libraries in the entire world. This building, dedicated in 1907, brought the engineering profession together on an intimate working basis, and for that reason has been of incalculable value in advancing the common objectives of all branches of the profession. Its affairs and those of the library are administered by the United Engineering Trustees, Inc., and the Engineering Societies Library Board, respectively.

In 1914, actuated by a desire to promote engineering knowledge, our own Past-President, Ambrose Swasey, established the Engineering Foundation as an instrument of several engineering societies to aid in the research activities of these bodies. His proposal was accompanied by substantial gifts that have reached a total of $750,000. With characteristic modesty and vision Mr. Swasey declined to have his name attached to the Foundation. In all his statements in connection with the Foundation he has expressed the hope that others will assist the progress of research by adding to the funds he has provided. I am happy to state that Mr. Henry R. Towne, another past-president, and Mr. Edward D. Adams have been inspired by Mr. Swasey's example to make substantial additions to the Foundation's endowment. The Engineering Foundation is now carrying on its work of aiding research in science and engineering, and of advancing in many other ways the profession of engineering and the welfare of mankind.



CONRAD N. LAUER

COOPERATION FOR THE PUBLIC WELFARE

Turning now to the relations of engineering societies with the public, it will be recalled that the World War provided a multitude of opportunities for engineers to serve the Government and the public without regard to their professional society affiliations on questions which required the competent advice of technically trained men. In order to make the services of individual experts of the engineering profession available and to provide an organization of authority and professional standing, the four Founder Societies formed the Engineers' Council in 1917. The services rendered by this Council proved to be valuable and effective, and demonstrated that in peacetime, as well as in war, there is a need by government bureaus, legislative and administrative departments, and other national bodies for unbiased and informed opinion on the engineering factors involved in questions of public interest. In 1920, therefore, the Council was reorganized as the Federated American Engineering Societies, subsequently renamed the American Engineering Council.

The formation of this body represented a significant change in the attitude of the profession toward the public. It calls together periodically in Washington representatives of many national and local engineering societies for the purpose of focusing the thinking of engineers for group service on national problems in which engineering principles and interests are involved. The American Engineering Council has been a powerful factor in developing a spirit of cooperation in the engineering profession. Its committees and representatives are highly respected by legislative and administrative agencies in Washington because they provide competent and disinterested advice on matters of public interest. It has sponsored a series of important studies on the relationship of engineering to industrial operations, such as those on waste in industry, the relation of safety to production, and the twelve-hour shift in industry. A committee of the Council is now preparing the groundwork for a study of the balancing of the forces of production, consumption, and distribution, a significant contribution to economic and sociological thinking.

State councils to perform locally services similar to those that the American Engineering Council renders to the nation at large have been formed in a few states, such as Minnesota, Colorado, and Utah, and offer further examples of the effectiveness of cooperation by engineering organizations.

COOPERATION FOR INDUSTRY AND THE ENGINEERING PROFESSION

The effectiveness of the cooperation of engineering societies with industry is demonstrated by developments in industrial and engineering standardization. Up to 1918 many bodies were engaged in the formulation of

such standards. In 1918 the American Engineering Standards Committee, now known as the American Standards Association, was formed through the joint efforts of five engineering societies, and ever since has grown in membership and in influence. Forty-five national organizations are now affiliated as member-bodies, and the Association is the official channel for international cooperation with similar national standardizing bodies in each of twenty foreign countries; it acts also as a clearing house for the distribution of information about standardization in the United States and elsewhere.

The registration and licensing of engineers, touching as they do the legality of the engineer's right to practice are also questions of common interest. While one state, California, had enacted a law in 1891 requiring registration and while there were altogether eleven states with licensing laws on their books in 1920, most of the discussion and interest in these questions on the part of engineers has developed since 1920. Fifteen states have put on their statute books some form of requirement for legal recognition of the engineering profession. Now, under the leadership of the American Society of Civil Engineers, a model law is being developed. There are at the present time twenty-six states with licensing and registration laws, and a body, known as the National Council of State Boards of Engineering Examiners, has been organized to provide a working arrangement for the coordination of procedure in the administration of these laws in the various states. This is an activity of increasing importance and interest.

The study of engineering education, undertaken in 1923 by the Society for the Promotion of Engineering Education, brought about the cooperation of engineering societies, industry, governmental agencies, and individuals throughout the entire range of the field of study. The elaborate report issued by that organization in 1930 gave a clear picture of the conditions in the schools and of the relationship between the education and training of engineers and the requirements of professional, industrial, and economic phases of modern life. It has provided the basis for sound advances in engineering education and in the profession itself, and demonstrated once again the value of cooperation.

In addition to the John Fritz Medal, already mentioned, other awards are made by several societies acting jointly so as to represent more completely the engineering profession of the United States in doing honor to men of attainment. The most recently established of these is the Herbert Hoover Medal, founded, in 1930, to signalize the public service of men who have gone outside of their strictly professional work to interest themselves in civic and human affairs. The medal is awarded by a joint board of the Founder Societies, and was first bestowed, in 1930, on the engineer-statesman whose name it bears.

A RECENT OUTSTANDING EXAMPLE OF COOPERATION

During the past two months seven engineering bodies, acting jointly, have formed the Engineers' Council for Professional Development. The purposes of the Council are to coordinate and promote efforts and aspirations directed toward higher professional standards in engineering education and practice, to enhance the prestige and solidarity of the engineering profession, and to secure greater effectiveness in dealing with technical, social, and economic problems. It will immediately concern itself with the development of a scheme whereby the progress of the young engineer toward professional standing can be recognized by the public, by the profession, and by the individual himself through the development of technical and other qualifications which will enable him to meet high professional standards. This is a conspicuous example of what extensive and comprehensive objectives may be set up by engineering societies working together in harmony and with intelligence.

The American Society of Mechanical Engineers is proud of the fact that the formation of this new body resulted from the work of its Committee on the Economic Status of the Engineer. But without the enthusiastic cooperation of the American Society of Civil Engineers, The American Institute of Mining and Metallurgical Engineers, The American Institute of Electrical Engineers, the American Institute of Chemical Engineers, the Society for the Promotion of Engineering Education, and the National Council of State Boards of Engineering Examiners, who joined with the A.S.M.E. in forming the Council, it could never have been hoped that this would become the truly representative and authoritative body that it now is.

THE PROBLEM OF UNIFICATION

These examples of engineers working together toward common objectives are concrete expressions of some of the ideals that are held for the advancement of the engineering profession. The objectives are worthy of the efforts expended for their attainment, and these latter have been organized with the idea of bringing about certain results useful either to the profession itself, to industry, which it serves, or to the public. However, it has been noted that many of these cooperative enterprises have necessitated the formation of organizations to carry out their projects. These organizations have grown both in number and in size. They have set up for themselves, or have been asked to set up, additional objectives. Their functions are not always clearly understood, with the result that there is danger of overlapping and a lack of clearly defined relationships among themselves and the engineering societies that have created them. The conclusion seems inescapable that the engineering profession is tending toward overorganization. It would seem that one of two alternatives must be chosen as a way out of our perplexing position. If we are to assume that these cooperative activities are more important than the numerous specific objectives for which individual engineering societies were formed, then the profession and the public would be well served by the consolidation of all engineering societies and related organizations into a single body that could act and

speak for the engineering profession. If these joint activities are merely those in which all engineering bodies can work most effectively through cooperation, then, by proper organization their usefulness can be assured and their procedure and relationship clarified and simplified without losing the undoubted benefits of the existence of long-established and vigorous societies, held together by common professional interests, whose very strength and progressiveness have given rise to these related bodies engaged in tasks of mutual concern and profit.

It is my opinion that the time is not ripe, and indeed it may never be ripe, to advocate the first of these alternatives, that is, the formation of a single engineering society to serve a profession which, in spite of its many common objectives, has so many specialized interests. The effectiveness of the existing major national engineering societies in dealing with the problems, practices, and procedures in the fields they represent is unquestioned, and the vigorous individual development of these societies must continue. Their joint activities must also continue and expand, as the individual societies collectively represent the profession and because common interests and objectives do exist. In general, the common objectives are:

1 The development of the individual engineer by selection, education, guidance, and recognition of his attainments
2 The focusing of the intelligence and knowledge that engineers possess on problems of public interest
3 The aiding of research and standardization in engineering and industry.

Joint agencies, therefore, may be in need of coordination and simplification, but not of consolidation. A committee representing the four Founder Societies is engaged in a study of this question. I believe that if the members of the engineering profession will support them, their findings may lead to this coordination and simplification. I do not believe that there exists a sentiment in favor of a single engineering society replacing not only the numerous organizations created by the present engineering societies, but those societies themselves as well. Rather I believe that sentiment is in favor of some form of my second alternative.

THE ENGINEERING SOCIETIES BUILDING, NEW YORK CITY—AN EARLY EXAMPLE OF COOPERATION

CONCLUSION

The numerous examples of successful cooperative endeavor which I have quoted demonstrate the practicability of achieving noteworthy results without destroying the autonomy of existing societies or diverting them from the purposes for which they were formed. It is an impressive indication of the vigor and progressiveness of these bodies that in a period of economic distress they have been able to bring about the formation of such a potentially useful and comprehensive organization as the Engineers' Council for Professional Development. This great accomplishment, which marks the beginning of an important epoch in the history of engineering, was made possible by the desire and ability of organized groups representing professional, educational, and governmental points of view to work together constructively and harmoniously in matters of common concern. No single engineering society embracing the entire profession could do more, and might, because of the inertia of its ponderous machinery, do even less.

Today engineers may look with renewed hope and enthusiasm to the unfolding of this new epoch. Every member of the profession, through the society to which he belongs because of his personal interests, has an active concern in a program of professional development that starts with the secondary school and carries on through the engineering college and apprenticeship in the profession to a final recognition of competency and attainment. Never has so comprehensive a program been laid before engineers with the machinery for its accomplishment ready for operation and the combined energies of long-established professional societies guaranteeing effective action. In attaining the objectives of this program, each engineering society will develop greater strength and prestige, and realize the fruits of former cooperative endeavors. All will find, I feel sure, as Dr. Thurston affirmed more than fifty years ago, that "the promotion of mutual welfare is consistent with the most perfect system of mutual cooperation and mutual aid in all the truest and highest aims of life."

The ENGINEER *in* PUBLIC LIFE

By DEXTER S. KIMBALL[1]

If the engineer is to be an important figure in public affairs he must acquire a broader technique than that which he ordinarily possesses, and he must inform himself concerning a wide range of subjects of which ordinarily he knows little. Furthermore he must acquire a wide knowledge of economic history and be able to trace the effect of economic changes over long periods of time.

The broad economic problems that now trouble us are not isolated and circumscribed in character; most of them have long histories and many ramifications. It is true that some of the old economic theories developed in a handicraft age do not apply to our modern machine era, and the industrial engineer can do much to show their fallacious character. But on the whole the engineer who aspires to solve modern economic problems must expect to do an unusual amount of studying before he can replace these old theories with others that are suited to our day and methods. Perhaps no field of knowledge presents such a bewildering array of theories which purport to tie together groups of phenomena more or less vaguely connected. He is indeed a bold man who will speak dogmatically about problems in political economy who has not studied this so-called "dismal science" long and carefully as a preparation.

If the engineer can apply his analytical methods to these vague relations and develop the basic facts through his more intimate knowledge of industry, he can indeed become a most useful factor in public life.

AN UNUSUAL feature of this period of industrial depression is the ever increasing outpouring of talks, magazine articles, pamphlets, and books by engineers discussing the economic problems that confront us. During the last year, as a member of a committee of the American Engineering Council it has devolved upon me to read a large amount of this literature, which varies from suggestions that obviously are of no help, to some profound studies of our present economic system and its defects. Of course, for many years a few forward-looking engineers have given thought to economic subjects, but the present activity is so great as compared with that of former days that one is led naturally to inquire into the reasons for this outburst. An examination of the growth of the engineer and engineering literature would appear to indicate that the phenomenon is quite logical and to be expected. Whether the engineer is to be of marked service in such matters, remains to be seen.

To many persons the idea of the engineer as a figure in public life is a new one, to say nothing of his appearance as an economist. But the increasing importance of engineering projects and of the manufacturing methods that the engineer has promoted were sure to push him into the lime light of public affairs. Not a few engineers have occupied such high offices as governors of states, and many have served on important governmental commissions, but without doubt the election of President Hoover has been the greatest encouragement to engineers to take a more prominent part in civic affairs. Is the engineer to be a prominent figure in the field where the lawyer and politician have been supreme?

During the last half of the last century the engineer was busy building up the vast and complicated industrial machinery which is now troubling us so much. He was rarely heard of in any other capacity. By the end of the century he had solved the problem of production for the first time in the history of mankind, and almost the first printed doubts of the economic consequences of his methods are found in the Census Reports of 1900. It was inevitable that this experience should be accompanied by great growth within the minds of engineers themselves, and engineering emerged in the new century as a scientific profession, whereas in 1850 it was largely a handicraft calling. Two major influences hastened these changes. The first is the essential nature of engineering, which leads naturally to an orderly method of thinking, not only as regards engineering, but also as regards all manner of problems. The second and greater influence has been the engineering colleges, of which the Land Grant engineering colleges constitute the large majority. The growth of engineering education during the last seventy-five years has been remarkable, and, in the last analysis, the college professor has been mostly responsible for the industrial development we now behold.

PROGRESS OF ENGINEERING THOUGHT AND PRACTICE DURING THE PAST FIFTY YEARS

The progress of engineering thought and practice during the last fifty years or thereabout can be traced admirably in the proceedings of the several national engineering societies. A good illustration is The American Society of Mechanical Engineers, founded in 1880. The early volumes of this society are decidedly "shoppy," and there is much discussion of elementary matters that have long since ceased to interest engineers in any large degree. Before long, however, scientific

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Presented at a meeting of the Land Grant College Association, Washington, D. C., November 15, 1932.

HENRY R. TOWNE

papers of real merit begin to appear, especially those concerning the theory of the steam engine and the strength of materials. As early as 1886 Henry R. Towne had presented a paper entitled "The Engineer as an Economist," and in 1889 he presented one of the first modern gain-sharing plans in another contribution to the society's Transactions. But progress was slow, and engineers as a whole were concerned with technical matters. In 1903 Fred W. Taylor presented his epoch-making paper on "Shop Management," and this marks a new era in engineering literature. It is almost unbelievable, looking back upon the progress of 30 years, to realize that this great paper, destined to change all of our ideas of manufacturing economics, was not only poorly understood, but even less appreciated. It is hard to believe that even ten years after Taylor's paper was presented it was sometimes difficult to get a hearing before this society for papers on the economics of production, but that this is a fact I can vouch for from personal knowledge. This is all the more remarkable when it is considered that 75 per cent of all engineers who graduate from college eventually find their way into administrative work of some kind.

ENGINEERING A PROFESSION HAVING AN INTIMATE KNOWLEDGE OF INDUSTRY POSSESSED BY NO OTHER GROUP

But if progress was slow it was sure, and engineering has emerged not only as a recognized profession, but also as one that has an intimate knowledge of industry possessed by no other group. And a part of this intimate knowledge is economic. A number of influences have forced this knowledge upon the profession. In industry the increasing pressure of competition has compelled the industrial engineer to develop a manufacturing economy almost wholly new. The electrical engineer was one of the first to be confronted with the need of a new manufacturing technique, which brought him into close proximity with manufacturing economy. In the case of the civil engineer the very magnitude of his projects has brought him face to face with economic problems of large size. Thus consider the new proposed bridge over the Golden Gate at San Francisco, which will have, if it is built, the longest span ever erected. So far as I am informed, no one has questioned the ability of the engineer to erect this giant structure, but the economics of the undertaking are much debated. This is typical of much of the work of the engineer today. The question, "Can it be done?" is not asked, but rather, "Should it be done from an economic standpoint?" From the very nature of his position in society, the engineer, if he is to rise to his opportunity, must be more of an economist than he is at present.

It is quite commonly assumed by some that the experience of the engineer in industrial economics should fit him to speak authoritatively upon the broader problems of political economy. It is quite true that the engineering administrator is brought into close contact with such matters as tariffs, taxes, transportation problems, foreign trade, etc., etc., and it is often assumed that to these problems he can bring the same methods of solution that he has found to be so successful in industrial problems. In many instances this is true, as illustrated by the excellent work already accomplished by the American Engineering Council in a field which a few years ago was unknown territory to engineers. Unquestionably where facts or tangible evidence can be obtained, engineering methods are very effective in arriving at accurate conclusions, and the engineer is in a peculiarly advantageous position in obtaining such tangible evidence, as can be gathered from the industrial field. However, in the case of our most difficult problems of general economics, exact facts and tangible evidence are not easy to obtain, and oftentimes the evidence is voluminous and conflicting. In many such cases the well-trained business man, or the lawyer, is just as capable, or more so, of drawing an accurate conclusion as any one else. Certainly the engineer has no advantage here unless the data are drawn largely from industrial sources with which he is more familiar than are others.

As Prof. Seymour Garrett, himself a well-trained engineer and also a successful teacher of economics, has well said:

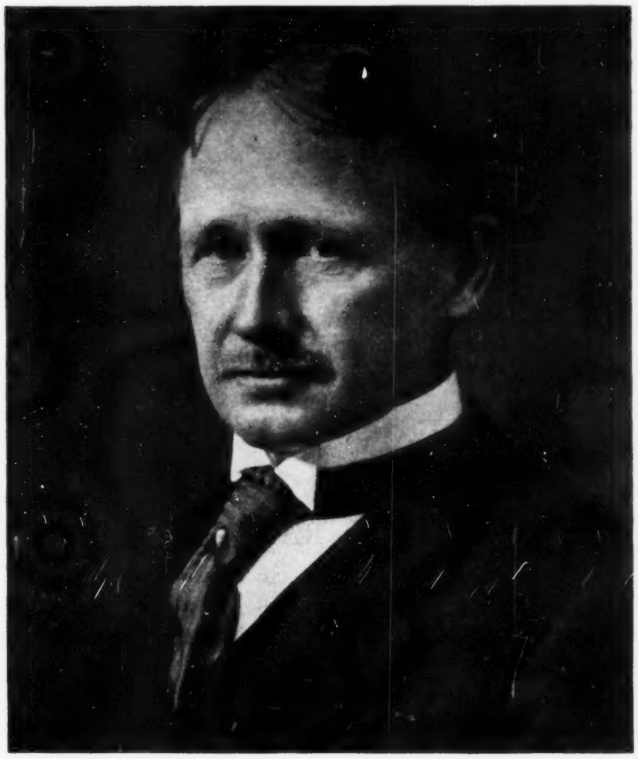
> I said above that the impossibility of drawing valid conclusions directly from the observation of events applied as well to current as to past economic affairs. I am aware that there is at the present time, and has been for some time past, a disposition to assume generalized theory unimportant. It is assumed that detailed statistical inquiry will reveal truth aided only by common-sense and general information. With this view, engineers, because of the nature of their own work and of their triumphs, have a natural sympathy. They instinctively

applaud what they denote as an appeal to facts instead of theory. What they forget, and sometimes do not even sense, is that the problems of engineering and of economics present large differences of kind. This is partly because the phenomena with which engineering deals occur in simpler form than those of economics. It is commonly possible to see without conscious effort just what is the nature of the data needed for a proper solution. Also the basic generalized theory within which the engineer works has been developed so long since that he uses it automatically and almost unconsciously.

BROADER ECONOMIC KNOWLEDGE ESSENTIAL FOR THE ENGINEER

If, then, the engineer is to be an important figure in public affairs he must acquire a broader technique than that which he ordinarily possesses, and he must inform himself concerning a wide range of subjects of which ordinarily he knows little. Furthermore he must acquire a wide knowledge of economic history and be able to trace the effect of economic changes over long periods of time. The broad economic problems that now trouble us are not isolated and circumscribed in character; most of them have long histories and many ramifications. It is true that some of the old economic theories developed in a handicraft age do not apply to our modern machine era, and the industrial engineer can do much to show their fallacious character. But on the whole the engineer who aspires to solve modern economic problems must expect to do an unusual amount of studying before he can replace these old theories with others that are suited to our day and methods. Perhaps no field of knowledge presents such a bewildering array of theories which purport to tie together groups of phenomena more or less vaguely connected. He is indeed a bold man who will speak dogmatically about problems in political economy who has not studied this so-called "dismal science" long and carefully as a preparation. If the engineer can apply his analytical methods to these vague relations and develop the basic facts through his more intimate knowledge of industry, he can indeed become a most useful factor in public life.

And in this preparation the assistance that the university may offer is comparatively small. It can provide the embryo engineer with a fair knowledge of industrial economics concerning plant location, plant design, plant operation, and plant administration. But in the broader field of general economics the best the university can do is to give him some fundamental training and some instructions as to the general character of these broader problems. The time available in the four- or even five-year course does not permit of anything more. But obviously if the college is to perform its duty to the engineer, who is sure to be brought into contact with world problems, it should do what it can along these lines. Not all or even many will become important figures in public affairs. That statement holds true for all college men from whatever course of study. But it would appear that the engineer who will take the time and trouble to inform himself concerning our broader economic problems should, with his peculiar knowledge of the industrial field, be able to make some very constructive suggestions that would be helpful in times like these.



FRED W. TAYLOR

PROBLEMS ARISING FROM GROUP CONSCIOUSNESS AMONG ENGINEERS

There is another and most important reason why broader economic knowledge is essential for the engineer, and that is the group consciousness now appearing among the profession. Only brief reference can be made here to this phenomenon. It has been said that one of the outstanding indices of a profession is the development of a "jargon" of its own that others cannot understand. In this the engineer, like the doctor and lawyer, has been highly successful. The second great index is a tendency on the part of engineers to exclude all but the elect from their group, as is the case with the medical, legal, ministerial, and other professions.

Until lately there has been little tendency among engineers to become an exclusive group, but the rapid growth of licensing and correlated movements indicate that a new era in this respect is under way. I have no quarrel with licensing if it be justifiable. If the engineer has become or will soon become such an important figure in the public eye that he should be licensed in order to protect the public, as is the case with the doctor, or lawyer, there can be no logical objection to such a procedure. If this is to be the case, the engineer must bestir himself and make himself fully worthy of such distinction. The lawyer not only practices law, but he is also a public servant in the creation and adjustment of law through his bar associations. The doctor not only attempts to relieve suffering directly, but he is a most important servant in matters of public health.

(Continued on page 60)

The MACHINERY INDUSTRY *at Grips With the* BUSINESS CYCLE

By W. H. RASTALL[1]

Although all types of business, at home and abroad, have been very seriously affected by the depression which has persisted since 1929, the American machinery industry has probably suffered more than any other; and now that it is suggested that business is beginning to improve, machinery manufacturers will probably find that they are in great need of a program which will in the future protect their enterprises from the losses and embarrassments experienced heretofore. For months these companies have been living on reserves, and probably for a further considerable period will find it necessary to depend largely upon such resources for their continued activity. In anticipation of future depressions it is highly desirable that conditions be studied in order that adequate reserves may be established to carry such enterprises past possible emergencies with safety.

The experience of the machine-tool industry is reflected in Fig. 1.[2] As was stated in a previous article, the peaks of the machine-tool curve rise to outstanding heights as compared with the booms of the general business cycle, and the valleys also sink to greater depths. In the collapse of 1919–1921, in fifteen months machine-tool orders fell to only 8 per cent of those of the previous peak. In the current cycle the high point for machine tools was reached in February, 1929, when the index number of the National Machine Tool Builders' Association stood at 336. The low point was reached in July, 1932, when the index number was 25.1, or 7.5 per cent of the preceding peak. Remembering that this is not the experience of a single firm but a collective report representing some seventy manufacturers, it will be recognized that the industry as a whole has been under unusually severe stress.

Other branches of the machinery industry are similarly

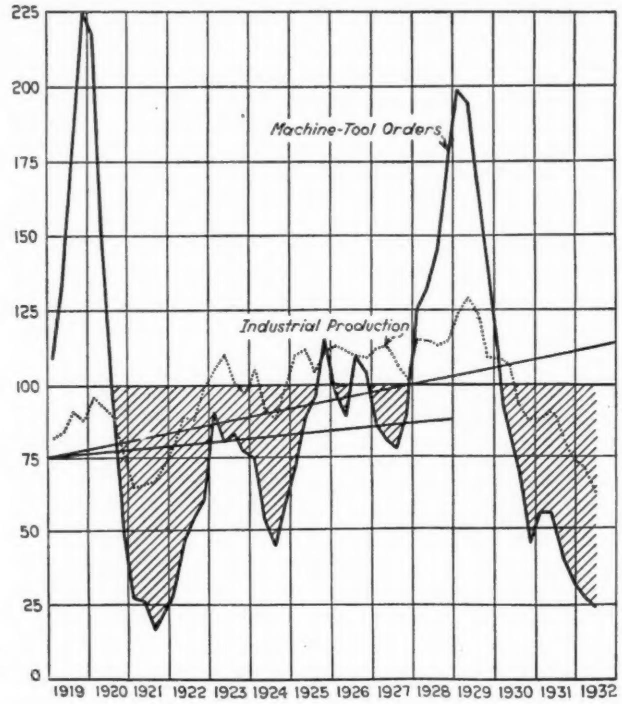


FIG. 1 FLUCTUATIONS OF MACHINE-TOOL ORDERS SINCE 1919 COMPARED WITH THOSE OF INDUSTRIAL PRODUCTION (1919–1929 average = 100.)

involved. In certain instances the experience has not been so trying, in others it has been worse.

It appears that there are only five machinery trade associations that collect the data necessary to compile such a curve, and their high and low index numbers have been as shown in Table 1.

TABLE 1 MACHINERY INDUSTRY INDEX NUMBERS, 1929–1932

	Index number	Decline, per cent
Machine Tools		
February, 1929	336	92.5
July, 1932	25.1	
Industrial Pumps		
April, 1929	151.9	82
July, 1932	27.3	
Foundry Equipment		
May, 1928	336	94
July, 1932	18.7	
Woodworking Machinery		
January, 1929	125.1	96
May, 1932	4.97	
Stokers		
June, 1929	123	81
May, 1932	23.10	

The worst situation of all appears to be that found among manufacturers of woodworking machinery, whose new orders have fallen to 4 per cent of the previous peak. The table provides explicit data showing the degree of collapse of new business in the case of manufacturers of five types of machinery, and there is reason to believe that if corresponding data were available in regard to the experience of manufacturers of other types of machinery, similar results would be revealed.

[1] Chief, Industrial Machinery Division, Department of Commerce, Washington, D. C.

[2] This chart brings down to date one published in Mechanical Engineering, March, 1932, page 182, in a previous article by the author, entitled "The Machinery Industry During Depression."

PRESENT CONDITIONS COMPARED WITH THOSE OF 1920

By 1931, 1.8 per cent of the machine-tool manufacturers of 1929 had gone out of business, 55.3 per cent of their wage earners had lost their jobs, wages had declined even more, namely, 67.2 per cent, and value added by manufacture, the item that appeals most to management and stockholders, 67.4 per cent, obviously creating a situation where it was necessary for an enterprise to rely upon reserves if it was to continue its existence. Further census returns are given in Table 2, where the experience of the current depression is contrasted with that of a decade ago. The figures for 1929–1932 suggest that management has been able to meet the situation more successfully than in the previous period, although it was extreme on both occasions. Perhaps a word of warning is needed, because it will be observed that the census years do not occupy quite the same position on the business cycle in these two instances. Referring to Fig. 1, in general the portions of the curve for the two periods resemble each other, with the exception that the depression of 1931–1932 is more protracted and consequently more serious because of the pressure on reserves that must necessarily follow from an experience of this kind.

TABLE 2 PRESENT CONDITIONS IN THE MACHINERY INDUSTRY COMPARED WITH THOSE OF A DECADE AGO

	1931	1929	Per cent of decrease	1921	1919	Per cent of decrease
Number of establishments	275	280	1.8	403	403	13.6
Number of wage earners (average for the year)	21,306	47,391	55.3	21,307	53,111	59.9
Wages	$25,062,306	$ 76,410,237	67.2	$25,252,000	$ 66,179,000	61.8
Cost of materials, fuel, and purchased electric energy	$22,110,356	$ 64,284,022	65.6	$23,975,000	$ 59,034,000	59.4
Products, total value	$80,954,449	$244,578,088	66.9	$67,729,000	$212,400,000	68.1
Machine tools	$54,865,487	$176,426,454	68.9	......	....	..
Value added by manufacture	$58,844,093	$180,294,066	67.4	$43,757,000	$153,366,000	71.5

AMERICAN INDUSTRY SUFFERING FROM LACK OF AN ADEQUATE EQUIPMENT POLICY

As was indicated previously, the conclusions that must be drawn from these data are that American industry in general is suffering because it has no adequate equipment policy. Machinery buying as reflected in the experience of the machine-tool group in 1919–1920 and in 1928–1929 represents buying anarchy. It indicates that there has been no continuity in the policy followed by corporations that have occasion to buy such equipment, and, conversely, that as soon as confidence weakens there is a paralysis of buying which necessarily must be taken into account by machinery manufacturers.

The absence of a rational equipment policy on the part of their customers necessarily forces machinery manufacturers to adopt management policies that will compensate for that lack. The machine-tool-order curve of Fig. 1 suggests that during the previous depression machine-tool builders were forced to live upon reserves for seven years, and the experience revealed by the chart down to date, together with the other figures given, suggests not only that these manufacturers may look forward to a similar difficult experience, but that woodworking-machinery manufacturers, foundry-equipment manufacturers, and others must also plan to overcome difficulties of a like nature.

An effort has been made to check these conclusions by a study of the profit experience of machinery builders. Although the census shows that there are about 10,000 concerns in the United States manufacturing industrial machinery, there are probably not more than one hundred of them whose securities are listed on the stock exchanges; these few, however, include many of the best institutions in the industry. Table 3 presents the profit experience for the last four years of those companies that publish reports, and it will be observed that 60 per cent of them show deficits for 1931. It is recognized that the data presented in the table are deficient in certain reports. Obviously the accounting methods employed by these eighty firms are not uniform, and there are instances where unusual circumstances have been reflected in the profits reported. However, a careful study establishes the fact that the typical machinery manufacturer was "in the red" in 1931, and in those instances where profits were shown it was because of some atypical experience, such as the control of a particularly valuable patent. A careful analysis of the profit experience of the companies listed in this table reveals what might be called the typical collapse of profits in the machinery industry. It also indicates that in a few favored instances methods have been employed to protect a given enterprise from the consequences of depression as experienced by the normal machinery manufacturer.

ECONOMIC CONSEQUENCES FLOWING FROM PRESENT SITUATION

Certain broad economic consequences flow from the situation revealed above. It has been calculated that the capital expenditures in the United States in 1929, that is, for machinery, buildings, power plants, dams, bridges, and the like—capital goods of all varieties—totaled over $15,000,000,000. As nearly as can be ascertained the corresponding present volume is not more than 25 per cent of the 1929 peak, which suggests that there has been a decline of nearly $12,000,000,000, equivalent, roughly, to the capital investment in the entire electrical industry of the country—estimated at $13,000,000,000. Obviously, any such collapse in capital investment starts a downward spiral in the general economic situation, resulting in outspreading waves of unemployment in all industries, with their disastrous

TABLE 3 NET EARNINGS OF MACHINERY MANUFACTURERS AFTER DEPRECIATION AND TAXES

Firm No.	1928	1929	1930	1931	Firm No.	1928	1929	1930	1931
1	1,223,000	1,297,000	900,000	535,000	41	1,040,689	1,332,000	589,000	100,194
2	240,307	219,000	69,000	211,241(*d*)	42	1,447,000	1,926,000	2,000,000	1,683,707
3	4,128,273	3,543,140	1,849,464	772,000	43	405,000	528,000	257,000	9,487(*d*)
4	1,428,161	2,645,000	2,931,000	1,716,000	44	288,000	347,000	37,000	....
5	447,599	530,000	78,000	222,000(*d*)	45	181,000	134,000	41,000(*d*)	....
6	1,225,842	1,433,775	1,374,630	605,980(*d*)	46	45,000(*d*)	274,000	96,000	144,728(*d*)
7	139,008	79,000	24,000(*d*)	111,000(*d*)	47	395,000	451,000	51,000	119,000(*d*)
8	203,100	204,000	42,000	....	48	3,241,823	3,484,686	2,310,332	638,973
9	570,781	564,256	211,000	194,698(*d*)	49	434,000	197,000	205,000	67,037
10	1,108,310	2,098,000	1,328,000	455,000	50	....	280,000	172,000	193,000(*d*)
11	17,461	204,000	121,069	29,374(*d*)	51	1,209,000	2,101,000	9,000	1,095,149(*d*)
12	2,687,177	3,302,000	2,439,000	823,976	52	277,000	461,000	34,000(*d*)	37,839
13	1,412,079	993,086	241,630(*d*)	369,000(*d*)	53	603,000	611,000	89,000(*d*)	287,106(*d*)
14	955,675	1,044,000	358,067	293,000(*d*)	54	91,000	161,000	274,000	335,160
15	....	102,000	80,000	....	55	374,000	534,000	685,000(*d*)	447,106(*d*)
16	632,000	845,000	515,000	83,943	56	350,000	383,000	268,000(*d*)	172,048(*d*)
17	290,000	143,000	68,000	57,903(*d*)	57	1,051,000	1,790,000	2,509,000	2,012,031
18	1,272,104	1,582,161	207,317	311,007(*d*)	58	2,512,000	2,707,000	922,000	23,052(*d*)
19	....	626,000	500,000	47,178	59	121,000	465,000	133,000(*d*)	398,261(*d*)
20	....	266,000	177,000	185,855	60	1,138,000	1,275,000	1,083,000	643,250
21	424,000	716,000	51,000(*d*)	(*m*)	61	607,734	1,309,422	443,981	462,158(*d*)
22	80,008	150,198	216,052(*d*)	....	62	1,392,995	1,446,874	761,571	454,116
23	913,000	1,023,000	845,000	648,000(*d*)	63	7,343,895	8,670,528	7,265,000	4,414,963
24	130,113	201,057	22,913	69,041(*d*)	64	319,000	185,000	391,000	374,640
25	141,000(*d*)	4,000	479,000(*d*)	494,842(*d*)	65	32,000	37,000	29,000(*d*)	....
26	1,405,000	1,130,000	327,000	91,376(*b*)	66	892,861(*d*)	1,004,034	890,340(*d*)	485,951(*d*)
27	2,161,671	2,348,671	821,612	5,168,054(*d*)	67	958,797	1,289,232	295,380(*d*)	1,543,959(*d*)
28	625,075	772,300	472,548	223,042	68	520,976	504,160	90,671	154,788(*d*)
29	581,000	407,000	27,000	189,000(*d*)	69	....	330,000	31,000(*d*)	111,783(*d*)
30	....	613,000	772,073(*d*)	718,481(*d*)	70	153,000(*d*)	308,000(*d*)	199,000(*d*)	384,000(*d*)
31	991,000	1,615,000	1,651,000	753,913(*d*)	71	60,000	108,000	55,000	....
32	....	615,000	251,000	513,000(*d*)	72	827,000	1,672,000	2,114,000	953,707
33	456,852	598,829	138,567	76,731(*d*)	73	....	199,000	22,000	180,055(*d*)
34	1,054,000	1,490,000	652,000	151,408	74	953,000	582,000	161,000(*d*)	618,000(*d*)
35	....	340,000(*d*)	247,000(*d*)	87,000(*d*)	75	247,000	280,000(9 mo.)	348,000	160,000
36	417,000	868,000	449,000	909	76	1,170,000	1,802,000	451,000	376,000
37	138,000	126,000	98,000(*d*)	467,209(*d*)	77	974,076	2,529,356	2,056,095	660,158(*d*)
38	986,000	1,241,000	66,000	1,254,001(*d*)	78	82,000(*d*)	328,000	373,000	32,547(*t*)
39	8,017,186	10,654,000	7,000,000(*e*)	165,721(*d*)	79	173,000	16,000	441,000(*d*)	624,264(*d*)
40	53,183	359,124	135,595	1,187,583(*d*)					

(*b*) Before certain charges. (*d*) Deficit. (*e*) Estimated. (*m*) Merged with another company, July, 1931. (*t*) Before Federal taxes.

consequences. It is difficult to say whether an improvement in the economic situation would correct the situation in the equipment industries, or, alternatively, whether a different equipment policy would correct the economic situation. In either event these returns emphasize the importance of the work undertaken by the Rehabilitation Committee under the chairmanship of A. W. Robertson, chairman of the board of the Westinghouse Electric and Manufacturing Company. Clearly, every encouragement should be given to Mr. Robertson and his associates, for their efforts appear to be the beginning of an equipment policy for American industry that will go a long way in the direction of correcting abuses that have existed heretofore, and thus protect the machinery trades from the buying anarchy and the buying paralysis reflected in the accompanying chart and statistics.

EFFORTS BEING MADE TO REMEDY SITUATION

Other efforts are being made to overcome difficulties of this general character. Some branches of industry and some of our important manufacturers are carefully developing definite policies for the guidance of management, not only in the procurement of equipment but in its maintenance and elimination, and surprising experiences have followed. Instances have been discovered where investments of a highly profitable nature were possible, the quality of product was improved, costs were reduced, and efficiencies raised. The rate of progress in the engineering trades has been accelerating, and those who will study the existing situation will unquestionably find business opportunities through the installation of new and better equipment that will abundantly repay the effort required.

For the first time we appear to have adequate data covering two crises which will enable machine-tool builders and other machinery manufacturers to understand their effects on the industry as a whole, and to adjust sales policies, price policies, and management policies generally in such a way as to insure protection hereafter. Also individuals in the machinery-building industries will find it desirable to plan definitely from now on. The census figures presented indicate that in the machine trades nearly 60 per cent of the wage earners lost their jobs. If we had monthly returns we should probably find that the percentage was even greater. We men who make machine building our life work should realize that a very serious hazard is presented to the industry by the business cycle, and that it is most necessary for us to adjust our personal as well as our business plans accordingly. While doing what we can

(*Continued on page 60*)

The PRESENT PROBLEM *of the* MACHINE

BY JAMES G. HARBORD[1]

The hum of the factory is as mute as the harp that hangs on Tara's walls, as mute as though its soul were dead. Meanwhile, depreciation and obsolescence have reigned in every idle factory in the land. The factories of America have run down at the heel. Everywhere machinery, equipment, and structures have suffered from neglect because maintenance and repairs have ceased.

If, by some miracle from on high, business should suddenly swell to normal proportions, there is scarcely a factory in the land equipped to fill its orders. Personnel scattered; machinery disabled; buildings out of repair—skilled individual industry has deteriorated through the fact and habit of idleness.

Equipment can be purchased and installed today at costs much below normal. Changes in equipment can best be made now while plants are not busy. Inventors have not been idle. Recent improvement in equipment offers unusual opportunity for cost reduction. Meanwhile it is obvious that the purchase of improved machinery and equipment will bring a positive and immediate stimulus to business recovery, just as the repair and rehabilitation of buildings and equipment will give employment to idle workers and increase their spending. Habits long forgotten will resume their sway.

I AM HIGHLY HONORED by this opportunity to address your distinguished body, The American Society of Mechanical Engineers. There is perhaps no professional group in the world more distinguished by scientific attainment, and none of higher character. Thirty-three years of my life were spent on the active list of the United States Army, perhaps the years of my life the most worth while. But it chanced that my coming into business synchronized with the rising tide of the machine age in both an industrial and military sense. An old cavalryman cannot be expected to be homesick for a service where the horse is replaced by a mobile tractor. In "days of old when knights were bold" the sarcastic foot soldiers said that nothing more was expected of cavalry than to lend an air of distinction in war to what might otherwise become a mere vulgar brawl. But conferring distinction from the upper deck of a galloping tractor is something that will have to be learned by another generation than mine. That old life is but a happy memory of days that can never come again, and I, like many other men, am today particularly concerned with the state of the manufacturing industries in this country.

BILLIONS NORMALLY SPENT FOR REPLACEMENTS AND REPAIRS

Ours is an industrial civilization. It is a machine age. The mechanical engineer is the master of the machine. He conceives and develops it. He operates the factories in which the machine is enthroned. He is the man to consult in any matter that concerns machinery. It is not inappropriate, then, that I should attempt to interest your Society in matters which deeply concern the production machinery of this country, on which in turn the earning power of the American people so largely depends.

In the past three years individuals and industries have undergone similar experiences. Men in their homes have thought it prudent to spend nothing for things the purchase of which could be delayed or avoided. Industries have done the same. Repairs ceased and maintenance came to a halt. In 1929, the peak year of our vanished prosperity, five and three-quarter billions of dollars were spent on new machinery, equipment, and plant facilities. Some of this vast sum was for expansion, but much was for current needs of the nation in the replacement and repair of the things that wear out and become out of date. The average yearly expenditure in the United States for this purpose in the booming years from 1919 to 1929 was four billion, eight hundred million dollars.

In normal times a very considerable part of the spending power of our people comes from their employment in this enormous business of industrial replacement and repair. For 1932, conservative estimates indicate that the total sale of this class of machinery and equipment will be a little less than a billion and a quarter dollars. This is about one-fifth the volume of the same business in 1929. Since that fateful year this kind of manufactured

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Address at the Annual Dinner of the A.S.M.E., Hotel Astor, New York, December 7, 1932.

products and service has remained unsold to the amount of over five billions of dollars.

These three years have witnessed the discharge of 1,619,000 workers in these capital-goods industries. The payrolls of those workers in normal times amount to over three billions of dollars a year. This money never received has of course not been spent. This payroll paralysis has in turn reduced the manufacture and sale of materials that would otherwise have been supplied to these capital-goods industries—steel, copper, textiles, and similar supplies. This, too, has meant idleness and a loss of purchasing power for all kinds of consumer products—clothes, food, motor cars, radio, and all the rest—and in still another field has thrown more men and women into idleness. For every capital-goods worker forced into idleness, three to four workers in other lines of industry have become unemployed, which means that some six and one-half million workers are now indigent and idle because American manufacturing industry has stopped buying. This cumulative effect cannot be measured in dollars alone. It strikes at the very integrity of our business life. It may, if unchecked, go to the very foundation of our free institutions.

FACTORIES OF AMERICA ILL PREPARED TO RESUME NORMAL PRODUCTION

The hum of the factory is as mute as the harp that hangs on Tara's walls, as mute as though its soul were dead. Meanwhile, depreciation and obsolescence have reigned in every idle factory in the land. The factories of America have run down at the heel. Everywhere machinery, equipment, and structures have suffered from neglect because maintenance and repairs have ceased. One plant has been robbed to keep another going; one machine has been doctored by spare parts obtained through crippling another. Much of the equipment originally installed in once going plants is now disabled. Much of that which is operating or going through the motions is running "haywire" and shrieking for first aid to the injured. American industry now faces the fact that when prosperity comes from around the corner where it has so long hidden and begins to build up the volume of production, its once thriving factories will come back, into a market now established on lower price levels, with costs too high to compete against more modern machinery and methods. If, by some miracle from on high, business should suddenly swell to normal proportions, there is scarcely a factory in the land equipped to fill its orders. Personnel scattered; machinery disabled; buildings out of repair—skilled individual industry has deteriorated through the fact and habit of idleness.

These are the conditions, here inadequately presented perhaps, even understated, which gave birth to the National Committee for Industrial Rehabilitation, of which Mr. Andrew W. Robertson, chairman of the great Westinghouse Electric and Manufacturing Company, is the head. Its purpose is to arouse manufacturers throughout the country to the necessity of at once modernizing their plants to put themselves in readiness for the return of better days. That is to say, at prevailing prices putting themselves in position to earn money so that they will enjoy a share of good times when the summer of prosperity blooms again. The Committee makes no emotional appeal. It points to no more than a patriotic duty. It calls for action dictated only by the soundest considerations of self-interest.

MODERN EQUIPMENT NOW AVAILABLE AT COSTS MUCH BELOW NORMAL

Equipment can be purchased and installed today at costs much below normal. Changes in equipment can best be made now while plants are not busy. Inventors have not been idle. Recent improvement in equipment offers unusual opportunity for cost reduction. Meanwhile it is obvious that the purchase of improved machinery and equipment will bring a positive and immediate stimulus to business recovery, just as the repair and rehabilitation of buildings and equipment will give employment to idle workers and increase their spending. Habits long forgotten will resume their sway.

Reemployment builds up by geometrical progression when men begin to go back to work. For materials and consumer goods must be provided at once. The man at the machine in the capital-goods factory must have raw materials. He begins to earn wages and seeks the opportunity to spend them for food and clothes. Some one must be employed to produce them. For every dollar spent for rehabilitation of plants and for every dollar spent to repair or replace worn-out equipment in an office, a warehouse, or a store, three dollars will be spent in consumer goods and materials industries, and more people will be put to work, thus speeding the recovery of general business. The impulse of returning prosperity travels like an electric current or a radio signal. Motors hum, wheels turn, cars move, men delve under the earth and fly through the air, steamships plow the seas, furnaces blaze, black men toil in the cotton fields of the South, the axe is heard in distant forests—all the manifold manifestations of prosperity are heard and felt in a land that again throbs with industrial life.

The committee of which Mr. Robertson is chairman believes that the hour is striking. If new elevators, or wider doors, or better floors in a warehouse will save money in the operation of a business, their purchase should not be allowed to wait. If new delivery trucks for a store will cut down the cost of operation, they should be bought now. If it would be profitable to install improved accounting machinery in an office, now is the time. It will all help increase the earning power of the company that makes the improvement, and will swell the volume of general business and make jobs for men and women in every corner of the land.

Such is the present emergency from one angle, and such the immediate program for which we ask your cooperation. There is yet another problem in which the mechanical engineers of our country should have an interest and do have a measure of responsibility. Given the restoration of plants and equipments in the dawn of the new prosperity, the workers again marching in

through the factory gates instead of marching on Washington, the bands again playing, and hearts again light—we are then no longer concerned in bringing back a prosperity already arrived, or in restoring the efficiency of production equipment, but in maintaining them both. What of the future? What insurance shall we take to keep the machinery from being neglected again? Can it be done? There are wise men who say that this is largely a point of view in management and in accounting. Like many other things in this life, it seems to get down to mere dollars.

LITTLE CONTROL TODAY IN THE ADMINISTRATION OF MONEY INVESTED IN MACHINERY AND EQUIPMENT

There is something like thirty billions of dollars in this country tied up—or tied down—in machinery. There seems to be little control or balance today in the administration of money invested in machinery and equipment. The rate of income which can be obtained from this vast sum of money—far beyond human comprehension—depends upon the efficiency of the equipment, that is, its capacity to turn out its work at low cost. How does the management of this investment compare with that followed when the same sum is invested in securities?

The business of corporations is, of course, all based on the use of raw money. This is borrowed by selling stocks and bonds. Then the money is used in buying plants and machinery, in the employment of men, the purchase of materials and the development and service of markets. Out of this nicely balanced operation of money, men, machinery, methods, and markets come the profits which go in interest and dividends to the people whose money is used by the company. It sounds simple and looks easy. It is plain, except for the adjustment of the operation which I have qualified as "nicely balanced." Therein, I am told, lies the chief problem of management.

There is no natural balance in these various phases of a business. The lack of it compels companies to resort to borrowing money when they need it, and to investing it in outside securities or loaning it to others when they have a surplus.

In this process of borrowing and of investing extra money, one of the basic principles of business has been developed. No company ever intentionally neglects it. It is elemental. We borrow money at the lowest obtainable rate of interest. We watch the market, and if money gets cheaper we refund by paying the old loan and taking out a new one at a better rate. When we invest we seek the maximum return consistent with safety. We still watch the market and maintain the high income from our investment by purchases of new securities that offer better earnings, and disposing of others not so good. Any management that does not so administer the loans and investments of its company is considered incompetent.

When it comes to the investment of money in equipment, in hiring men, in developing markets, and in maintaining credit, this principle is neglected to an astonishing degree and the balance is lost. This notwithstanding the fact that the principle is as applicable in the one transaction as in the other. The attitude of management toward raw money transposed into plant, equipment, personnel of trained employees, or into the business of customers, or into established credit, is seldom the same as when that money goes into securities. The development, maintenance, and conservation of a high return from these sources is not looked upon or identified as a matter of administering money. It becomes lost in a maze of purposes, policies, and traditions revolving around factory management, production schedules, labor relations, sales programs, and the stock market. The six per cent legal rate of interest sticks up like a beacon to steer by in administering money put into securities. No such beacon seems to shine when the same money goes into machinery, men, and markets, or stands erect to indicate an earning power as a goal for the management.

The management that wisely disposes of securities when they cease to give reasonable returns on the investment should, on the same theory, get rid of machines that cease to pay a good rate of return and replace them with machines that will pay better. As machinery depreciates through wear and turns out work with less efficiency and at higher costs, it should go to the junk pile. When a machine becomes obsolete through the development of a more efficient one for doing the same work better and at less cost, it should be scrapped and a new one substituted. These dogmatic statements sound like common sense, but they are far from stating the rule in practice.

NEARLY HALF OF THE ENTIRE MACHINE-TOOL EQUIPMENT OF AMERICAN INDUSTRY NOW OVER TEN YEARS OLD

According to a recent survey made by the *American Machinist*, 48 per cent of the entire machine-tool equipment of American industry is now over ten years old. During that period the productive efficiency of machine tools has been improved something like 300 per cent. Half of its machine tools being out of date, American industry is today wasting on its factory operations a startling amount of money. "Wasting" is the word, because the improved equipment will turn out more work per hour with each modern machine, which means that the same production can be obtained from fewer machines at less cost per unit of output.

How is it that American factories, with our boasted shrewdness and efficiency of management—in which we think we lead the world—carry the burden of so much obsolete equipment? Is it not principally because of faulty bookkeeping and lax financial control?

The average corporation charges off depreciation on machinery each year, but too often it means to the management merely an account on the books. The total investment shown on the annual statement is reduced by a given percentage for the worn machinery. But the actual sum corresponding to the depreciation shown is left in the regular bank account and paid out for whatever seems the need of the moment. I doubt not that

there are many executives to whom it does not occur that the amount charged off for depreciation has anything to do with actual replacement of the depreciated machinery. It is not always, or even often, set aside for that purpose. There are many depreciation accounts that consider only wear and ignore obsolescence, which latter actually depreciates the equipment as much as wear and tear. Often no charge is made for mere obsolescence. It simply does not figure in the planning and operation of the average business. When the improved machinery of a competitor so reduces production costs that he begins to take away the business, management is roused to the fact that plant efficiency has run down, that new machinery must be bought, and that no money has been set aside to finance the purchase.

PRESENT METHODS OF BUYING MACHINERY INEFFICIENT

Most machinery seems to be bought under such circumstances. Or it is bought when business is rapidly increasing and spending is free, because the management is enthusiastic over invading new markets, bringing out new products or increasing the old ones. It is easy to get appropriations out of the board of directors under those circumstances. In any event, however, it is a hand-to-mouth, slipshod, inefficient method of doing business. It is the incompetent management of the earning power of all those dollars invested in machinery. It is inefficient in direct proportion to the extent it diverges from the proper method of handling money invested in securities. It should be parallel instead of divergent.

It takes nerve to buy new machinery for a declining business, and it often presents a serious financial problem, but if a regular funded reserve is set aside each year in the form of money invested in bonds or other securities and held for use in modernizing equipment, the income from plant and machinery can be sustained in as orderly and dependable a manner as the income from security investments. This done, the process of replacing worn-out or obsolete machinery becomes extremely simple.

Every machine should be tested periodically by comparing its production cost with that of the most improved machine available for doing the same work. When the old machine reaches the stage where it costs more to operate it than to invest in the new one, the works manager should submit the case and make requisition on the equipment replacement fund. It is a minor and not a major operation. If the requisition is approved, the new machine is bought.

REPLACED MACHINERY SHOULD BE SCRAPPED, NOT SOLD

Two things should be thought of in this connection, and strictly observed. There is always the temptation to sell the old machine to a second-hand dealer. When you do that you help some one start a new factory, with small overhead, to "bootleg" your particular product. In boom times it is easy thus to demoralize the market by inducing prices which the established competitor cannot meet, and by inflating the productive capacity of the industry. When the old machine goes, it should go for junk. It should not be sold otherwise, even for a higher price. The replacement calculation should take this into consideration.

Again, when new machinery takes the place of the old, the replacement should be made not machine for machine, but on a basis that will provide no more than the desired capacity. For example, eight new machines may turn out as much as ten of the old models. If so, to buy only the eight will be to realize the maximum economy and avoid inflation of capacity. Some may question this last suggestion because it means the employment of fewer workers. The experience of mankind is against this theory. Technological improvements of this kind do the opposite, for they make it possible for one man and one machine to create more wealth, and thus provide new jobs elsewhere. Such technological unemployment is soon adjusted by the ebb and flow of other work.

Between 1920 and 1927, for instance, was the period of most active mechanization in American industry, and over half a million people lost employment in factory work. During the same years a million and a quarter workers lost their work in agriculture. They were all of them absorbed in mercantile, clerical, contracting, and other pursuits, most of this being made possible by new industries created by mechanization, such as the automobile, moving-picture, and radio industries. As a matter of fact, the proportion of our people gainfully employed in 1880 was 34.7 per cent, while forty years later, with all our increase in population due to immigration, the percentage had risen in 1920 to 37.6 per cent. Increased mechanization does not in the long run reduce the number of jobs in a country.

FUNDED RESERVES SHOULD BE CARRIED TO CARE FOR DEPRECIATION AND OBSOLESCENCE

There is no reason why the efficiency of the machinery in use in industry cannot be maintained in as thorough and orderly a manner as security investments are maintained. It can be done if companies will carry a funded reserve for correcting depreciation and obsolescence in equipment. Inflation of capacity both in the plant and in the industry can be avoided if there is a definite policy on equipment replacement to prevent it.

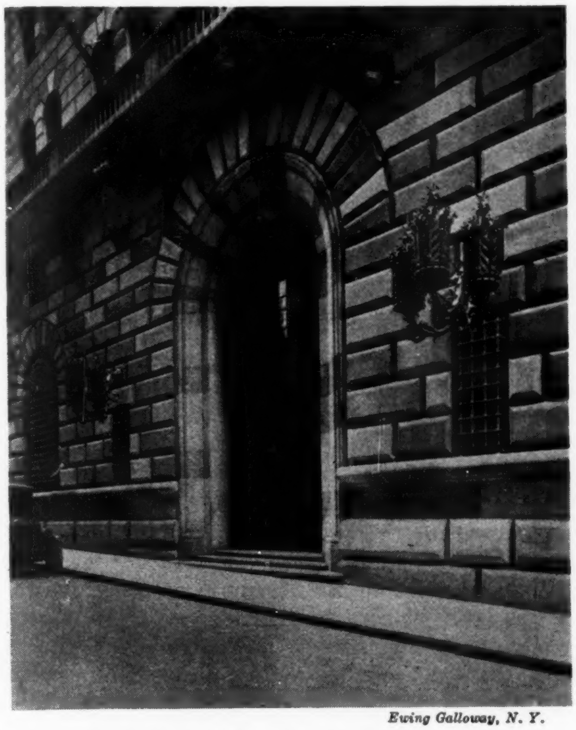
These are sober themes, but you are sober men. Perhaps it is not too much to say that they are dry subjects in a "dry" time. I can hardly presume that anything I have said has come to you as either new or original. If I have said anything to amuse you, it has not been done intentionally. You are one of the highly representative groups of those men who are best and most useful in American life. I know of no group of men whose influence can be more constructive in the closing days of this emergency, and in the preparation for the better days that I believe are near at hand. I therefore take advantage of the invitation with which you have honored me this evening, and appeal to you for your support and cooperation in these objectives, if by happy chance I have suggested anything that commands the endorsement of your trained judgment.

Strengthening Our BANKING STRUCTURE—II

Interdependence of Banks—How Banking Institutions Function—Making Safe Loans—Group Banking—Fewer and Larger Banks

By JAMES L. WALSH[1]

IN THE preceding article on this subject,[2] it was pointed out that the banking system (or lack of system) under which Americans endeavor to transact their business comprises fifty widely varying banking codes—one for national banks, one for each of the forty-eight states, and one for the District of Columbia. After noting that one-third of our banks, over ten thousand in number, have suspended operations during the past ten years, with the permanent loss or temporary tying up of $4,345,000,000 of depositors' funds, the question was raised as to whether this tragic record was avoidable or not. Examination of the structure of the banking systems in other countries than the United States indicated a far better record than our own, particularly in England and in Canada, where no depositor has as yet, during this depression, suffered the loss of even a single dollar. Authorization for national banks to establish branches throughout the limits of the state in which located, irrespective of restrictions of state law, was urged as a step in the right direction.



Ewing Galloway, N. Y.

ENTRANCE TO FEDERAL RESERVE BANK, NEW YORK, N. Y.[3]

It should be emphasized here that the discussion in the first article was directed solely toward the strengthening of the *structure* of banking. It is recognized that sound policies and capable management are also essential to banking stability. Regardless of structure, poor management can, and probably will, yield disastrous results. However, even with excellent management, it is doubtful whether satisfactory performance can be attained so long as the structure itself is of unsound design.

The fact that 4851 banks suspended operations during the seven-year period ending in the fall of 1929, appears to justify the contention that our heterogeneous collection of fifty different banking codes permitted the erection of a structure which failed to stand up against even ordinary stresses, and which contributed to the severity and length of the depression when real difficulties were encountered—during 1930, 1931, and 1932. In order to appraise potential advantages which may reasonably be expected from the suggested remedy—state-wide branch banking—it may be found helpful to break down into its elements our present banking structure and examine its parts somewhat in detail. In doing so, it is possible that some popular misconceptions in regard to banking will be explained and, to a certain extent, dispelled.

In order to simplify matters, this discussion will be confined to the operations of an ordinary commercial bank with a savings department—the typical set-up in a city of moderate size. Consider first the so-called "unit" bank, its capital drawn from local sources, its officers and directors selected from residents of the city, its depositors comprised entirely or largely of local citizens, corporations, and governmental units, and its borrowers substantially of similar origin. A unit bank is sometimes erroneously referred to as being an "independent" bank. No bank, large or small, is really independent in the final analysis.

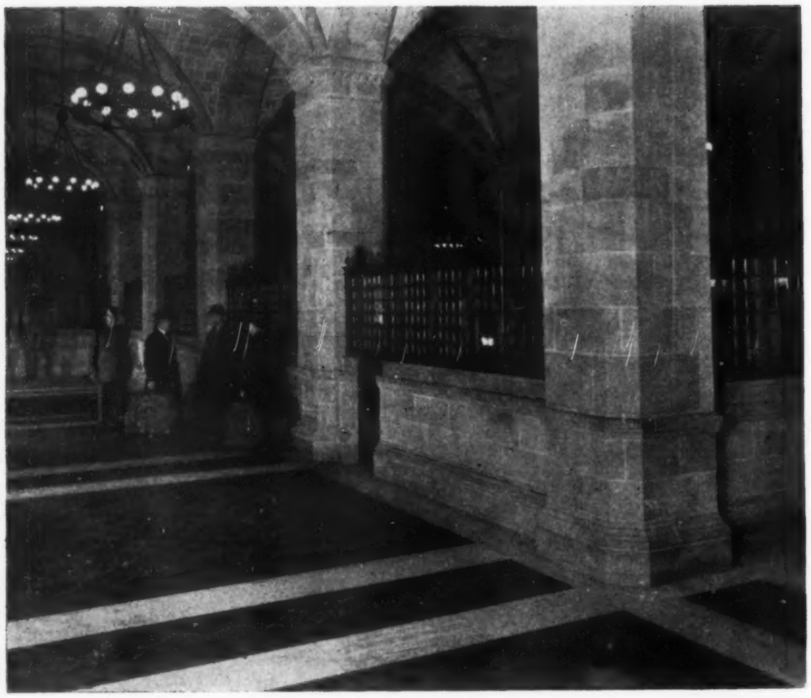
INTERDEPENDENCE OF BANKS

In his address in St. Louis, Missouri, on November 5,

[1] Executive Vice-President, Guardian Detroit Union Group, Inc., Detroit, Mich. Mem. A.S.M.E.

[2] Mechanical Engineering, December, 1932, p. 825.

[3] Photographs in this article not otherwise credited were furnished through courtesy of Federal Reserve Bank, New York, N. Y.



MAIN BANKING ROOM, FEDERAL RESERVE BANK, NEW YORK, N. Y.

1932, President Hoover graphically demonstrated the dependence of a multitude of small banks on a single large metropolitan bank. In brief, due to the successive failures of more than a hundred small neighborhood (unit) banks in the outlying portions of our second-largest city, depositors of a large down-town (unit) bank became alarmed and, in increasing numbers, demanded their funds. Among the depositors of the threatened down-town bank were 755 other banks, the great majority of these (unit) banks being located in towns of less than 5000 population.

The deposits of these 755 banks constituted part of their cash reserves for payment of their own depositors when, as, and if demanded. Hence the closing of the large bank would of necessity have adversely affected the ability of the 755 depositor banks to take care of their own depositors—estimated at 6,500,000 in all. But, in addition, these 755 banks had 21,000 deposit accounts from still other banks (including obvious duplications). All these would have been weakened and many of them might easily have been closed by the chain of events set in motion by the closing of the single large bank. That small (unit) banks are in great measure dependent upon large banks is fairly plain, and similarly, although not so obviously, large banks are dependent upon smaller banks. This latter aspect of interdependence among banks was touched upon in the preceding article, where it was pointed out that the suspension of over 10,000 banks (over 90 per cent of them located in towns of less than 10,000 population) during a ten-year period had temporarily tied up or permanently wiped out over $4,345,000,000 in depositors' funds. This necessitated the sale of investment-bond holdings or liquidation of loans to an equivalent amount in endeavors to satisfy the demands of depositors in these 10,000 closed banks. The adverse effect upon the bond portfolios and collateral cards of remaining banks, large and small, is apparent, and yet some bankers cry "Independence! Independence!" when there is no such thing as independence in the banking world —to paraphrase a well-known saying. Now the building of an army starts with the individual soldier. His physique, his equipment, his training, and his morale determine the effectiveness of the successively larger units into which he is organized. So the building of a banking system must start with the individual—in this case the depositor. His stability of earning power and his psychology determine the stability of the bank in which he deposits his funds, and influence the bank's ability to serve its community through the extension of credit. Bank depositors are the primary "creditor class," and a bank's responsibility to its depositors is paramount to every other consideration. Here we sense another popular misconception: namely, that a bank should at all times be ready to make loans to every one desiring credit, and should at the same time keep all deposits not merely safe, but available on demand. These two requirements are obviously inconsistent.

The funds deposited in a bank are not left there in the exact form in which received and subject to the call of the depositor, but must be loaned, or invested, promptly in order to yield the bank a sufficient return, after deducting all necessary expenses, to permit payment of a reasonable rate of interest to the depositor for use of his funds, and to set aside reserves to meet the inevitable losses which are part of the risk of the business. In effect, a bank borrows from its depositors and loans portions of these funds to its borrowers. Hence, when the depositor, through necessity, or fear, demands payment of his loan (deposit) from the bank, the bank in turn must demand payment of a corresponding amount of its demand loans, refuse to renew time loans at maturity, or sell some of the bonds in its investment holdings.

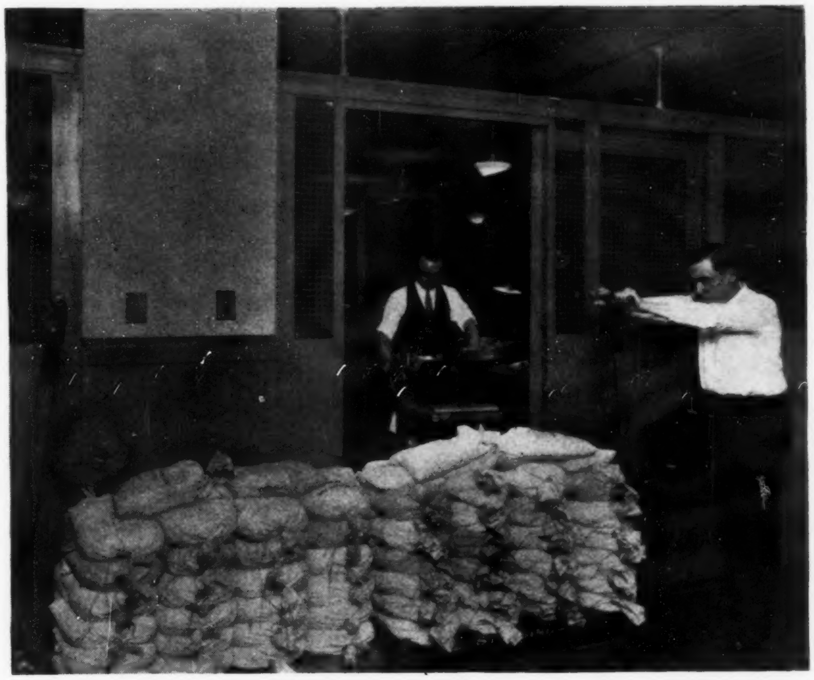
In effect, bonds held for investment are merely transferable, marketable loans to governments, corporations, or municipalities subdivided into convenient denominations to facilitate purchase and sale. In normal times the probable demand of depositors for their funds can be forecast with considerable accuracy, taking into account cycles of production in various industries, seasonal movements of commodities and finished products, etc. Knowing approximately what the demands are liable to be, the percentage of deposits to be maintained as "cash in vault" and "on deposit in other banks"

subject to immediate withdrawal can be determined, always including the funds required to be left on deposit in the Federal Reserve Bank (if a member of the system) in accordance with the provisions of statute law.

The remaining portion of total deposits is available for investment in bonds, loans to individuals, firms, or corporations to facilitate routine transactions incident to industry and trade, loans secured by pledge of suitable collateral, real-estate mortgages, etc.

THE COMPLETELY LIQUID BANK OF LITTLE VALUE TO ITS COMMUNITY

In order to make a bank completely safe, that is, to be in a position to pay off all of its depositors in full upon demand, it would be necessary for the bank to maintain an amount equivalent to 100 per cent of its deposits in the form of "cash in vault," or "on deposit in Federal Reserve Bank and other banks," with possibly a small portion invested in United States Government bonds or certificates, for which an immediate market continuously exists. The bank would then be said to be "100 per cent liquid"—but it would be of little use to its community, to agriculture, industry, or commerce generally, and it would be unable to pay any interest on its deposits, or any salaries, or rent, or taxes, or any other expenses incidental to the operation of a bank.



COIN-COUNTING AND INSPECTION DEPARTMENT, FEDERAL RESERVE BANK, NEW YORK, N. Y.

On the other hand, a bank can be so liberal in the extension of credit to its borrowing customers that it will have an insufficient amount of the depositors' funds held as "cash in vault" or "on deposit in Federal Reserve or other banks," or invested in readily marketable bonds, or sound loans payable on demand—that it may find itself embarrassed when it attempts to realize upon its loans and investments and produce cash to meet the rightful demands of its depositors. Under these circumstances the bank is referred to as having "frozen assets." If the time comes when it can no longer meet the demands of any single depositor, it must suspend operations and prepare to distribute its assets to all remaining depositors pro rata.

The art in banking is to forecast probable trends of the depositors' demands, so as to provide cash, or its equivalent, immediately available for all normal withdrawals and yet have invested in earning assets a sufficiently high proportion to yield the return necessary to provide for salaries of management, rent, taxes, equipment, interest on depositors' funds, etc., etc.

When the depositor becomes panicky he is apt to demand his funds in far greater volume than could reasonably have been forecast in normal times. Moreover, as banks in the vicinity begin to close, the prudent banker must, of necessity, take necessary steps to insure that a greater and greater percentage of his funds are immediately convertible into cash to meet demands of depositors. Of necessity a contraction in credit ensues. Possibly the bank endeavors to anticipate threatened withdrawals and, naturally, hesitates to make any new loans, even on a sound basis, unless they are eligible for rediscount at the Federal Reserve Bank or convertible into cash through payment by the borrower or transfer to another institution.

Through this entire train of events the fact should not be lost sight of that the psychology or financial condition of the depositor is the paramount factor in determining the attitude of the bank toward existing or potential borrowers. Hence it is entirely inconsistent to condemn a bank for "hoarding" (i.e., maintaining an unusually high degree of liquidity) and at the same time expect it to be in a position to pay off all its depositors on demand.

ANALYSIS OF THE STATEMENT OF CONDITION OF A TYPICAL COMMERCIAL BANK

In order to permit a clearer conception of the interrelationship of the factors involved, the routine statement of condition of a typical commercial bank, with a savings department, is given in Table 1. For greater ease in determining "liquidity," the various classes of assets have been rearranged in the order of their relative liquidity, as shown in Table 2. The average earning rate of the various classes of deposits is indicated in the right-hand column.

Currency held in the bank's vaults earns no interest; nor do funds held on deposit in the Federal Reserve Bank. Furthermore, funds on deposit in metropolitan

TABLE 1 THE X.Y.Z. NATIONAL BANK—STATEMENT OF CONDITION AS OF SEPTEMBER 30, 1932

Resources			Liabilities		
Cash in Vault and in Banks		$ 35,390,361.10	Capital Stock	$10,000,000.00	
United States Government Securities	$19,620,603.17		Surplus	5,000,000.00	
Municipal and Corporate Bonds	12,594,823.90	32,215,427.07	Undivided Profits	702,148.69	$ 15,702,148.69
Stock of the Federal Reserve Bank		660,000.00	Reserves		1,769,195.97
Loans and Discounts		65,301,495.21	Liability under Acceptances and Letters of Credit		228,812.50
Real-Estate Mortgages		17,732,533.53	Circulation Notes Outstanding		4,999,980.00
Accrued Interest Receivable		629,811.61	Deposits		137,888,608.61
Banking Quarters and Other Real Estate		8,430,304.75			
Customers' Liability under Acceptances and Letters of Credit		228,812.50			
Total Resources		$160,588,745.77	Total Liabilities		$160,588,745.77

TABLE 2 THE X.Y.Z. NATIONAL BANK—STATEMENT OF CONDITION AT CLOSE OF BUSINESS SEPTEMBER 30, 1932

	Amount	Per cent of deposits and circulation	Average earning rate, per cent
We have Cash in our vaults and on deposit in Federal Reserve Banks and other banks	$ 35,390,361.10	24.767	0.87
We own U. S. Bonds and Certificates	19,620,603.17	13.731	3.45
Cumulative	55,010,964.27	38.498	...
We own Municipal, State, and Other High-Grade Bonds	12,594,823.90	8.814	5.07
Cumulative	67,605,788.17	47.312	...
We own Stock in the Federal Reserve Bank of which we are a member	660,000.00	0.461	6.00
Cumulative	68,265,788.17	47.773	...
We have loaned on Readily Marketable Collateral and to Merchants, Manufacturers, and Business Men of approved credit standing for commercial purposes	65,931,306.82	46.141	5.31
Cumulative	134,197,094.99	93.914	...
We have loaned on Real-Estate Mortgages not in excess of 50 per cent of the value of the real estate	17,732,533.53	12.410	6.00
Cumulative	151,929,628.52	106.324	...
Our Banking Quarters and Equipment are worth, after deducting depreciation (including other real estate)	8,430,304.75	5.899	...
Cumulative	160,359,933.27	112.223	...
Customers' Liability under Acceptances and Letters of Credit	228,812.50	0.160	...
Other Assets	....	.....	...
This makes a total amount on hand to meet all obligations of	$160,588,745.77	112.383	...
Against this amount we have deposits and circulation	$142,888,588.61	.....	...
Customers' Liability under Acceptances and Letters of Credit	228,812.50	.....	...
And for the further protection of our depositors we have in Capital, Surplus, Profits, and Reserves	17,471,344.66	.....	...
	$160,588,745.77	.....	...

banks in the larger financial centers earn not more than 1 per cent. Accordingly, the average earning rate of the most liquid of the bank's assets is but 0.87 per cent. The next most nearly liquid category of assets is that proportion of the depositors' funds invested in U. S. Government securities—which would yield an average of but 3.45 per cent. Obviously, if the bank confined its loans and investments to these two highly liquid classes, it would approximate "100 per cent liquidity," but the average earning rate would be so meager as to preclude the bank's meeting its necessary expenses of operation, including payment of interest to its own depositors. Furthermore it would be of little value in stimulating industry, trade, and agriculture in the community which it was organized to serve.

Through investing its funds in municipal and corporate bonds, however, it not only obtains a higher average earning rate (5.07 per cent), but it thereby enables cities and states to build highways, schools, and public buildings; public-utility corporations to build power plants, gas tanks, water works, and telephone systems; railroads to lay new rails, modernize terminal facilities, and build new freight cars; and industrial corporations to build industrial plants and install productive machinery. Obviously it is this class of investments, among others, which create work for many hands. Loans to individuals, corporations, and municipalities similarly create employment, through aiding manufacturers to purchase raw materials for conversion into finished products and meet their payrolls during the period of production. Loans to individuals for the purpose of carrying securities in turn help to build more factories and schools and bridges and public-service facilities.

That proportion of the depositors' funds reloaned in the form of real-estate mortgages finances the building of homes, hotels, office buildings, factories, setting up a

beneficent cycle of interchange of goods and services through the purchase of lumber, cement, plumbing, etc., and the employment of carpenters, plasterers, paper hangers, etc. Obviously too high a proportion of the depositors' funds cannot safely be reinvested in this type of asset, because the real-estate mortgage is neither rediscountable at the Federal Reserve Bank nor readily marketable to other institutions, in the event it becomes necessary to convert assets into cash for the purpose of paying off depositors. However, it does have the advantage of a relatively high average earning rate.

FUNDAMENTAL PRINCIPLES GOVERNING THE SAFE LOANING OF MONEY BY BANKS

In 1863 Hon. Hugh McCullough, the first Comptroller of the Currency, enunciated certain fundamental principles governing the safe loaning of money by banks. Good advice then, these principles are more than ever pertinent today:

> Let no loans be made that are not secured beyond a reasonable contingency. Do nothing to foster and encourage speculations. Give facilities only to legitimate and prudent transactions. Make your discounts on as short time as the business of your customer will permit, and insist upon the payment of all paper at maturity, no matter whether you need the money or not. Never renew a note or bill merely because you may not know where to place the money with equal advantage if the paper is paid. In no other way can you properly control your discount line, or make it at all times reliable.
>
> Distribute your loans rather than concentrate them in a few hands. Large loans to a single individual or firm, although sometimes proper and necessary, are generally injudicious and frequently unsafe. Large borrowers are apt to control the bank; and when this is the relation between a bank and its customers, it is not difficult to decide which in the end will suffer. Every dollar that a bank loans above its capital and surplus it owes for, and its managers are therefore under the strongest obligations to its creditors, as well as to its stockholders, to keep its discounts constantly under its control.
>
> Treat your customers liberally, bearing in mind the fact that a bank prospers as its customers prosper, but never permit them to dictate your policy.
>
> If you doubt the propriety of discounting an offering, give the bank the benefit of the doubt and decline it; never make a discount if you doubt the propriety of doing it. If you have reason to distrust the integrity of a customer, close his account. Never deal with a rascal under the impression that you can prevent him from cheating you. The risk in such cases is greater than the profits. [In brief, always play an adverse "hunch."]

Violation of the advice of Mr. McCullough, "*Distribute your loans* rather than concentrate them in a few hands," is, more than any other single factor, the root of the troubles of the ten thousand small banks which have suspended operations during the past ten years. Serving a locality of limited area, it is apparent that it is practically impossible to secure proper *diversification* of risk. Hon. Ogden L. Mills, Secretary of the Treasury, in his report for the year ended June 30, 1932, as published on December 7, 1932, states:

> Various studies that have been made point to unescapable conclusions. The mortality rate is much greater among small banks than among the banks with larger resources. The earnings of most of the smaller institutions over the period of the last few years have been entirely inadequate, making it impossible for them to build up reserves. The cost of operation, and consequently the cost to the community which it serves, bears a direct relationship to the size of the bank. This is particularly true of the great number of institutions with limited resources that were operating in 1920 at the time the number of banks reached the maximum. The losses sustained by the smaller institutions have been relatively greater; and it is unquestionably true that a great number of the small banks have been unable to secure proper management.
>
> This does not mean that mere size will of itself guarantee good banking or a sound banking structure. These facts, however, do indicate that the operation of a vast number of independent unit banks under such conditions—that it is difficult for them either properly *to diversify their assets*, to make earnings, to procure competent management, or to command adequate resources—is a definite source of weakness in the American system of banking.

The so-called McFadden Act, approved February 25, 1927, permitted national banks to establish and maintain branches within city limits in those states in which state banks were permitted to have branches. It thereby assisted the large metropolitan banks to increase still further their already satisfactory degree of diversification of loans. However, it extended no relief whatever to banks of medium or small size, outside of the larger cities. In fact, it made their position somewhat worse through preventing, within the Federal Reserve System, consolidations outside of city limits in those states which permitted branch banking.

GROUP BANKING

In order to meet a real economic need it was necessary to find some legitimate means of bringing together many scattered banks in order to afford greater diversity of credit risk and resultant greater safety to the depositor. By a natural and logical process of development, the idea of so-called "group banking" was evolved. This development, which has made great progress during the past few years, comprises ownership, through a holding company *managed by bankers*, of a group of banks more or less integrated in management with the central bank of the group. Group banking should not be confused with so-called "chain banking," which involved usually the complete or partial ownership by an individual or group of individuals of a number of separate institutions without effort to coordinate management or mobilize the resources of all for the greater safety of each of the constituent units. As a matter of fact, in too many cases chain banking was the result of the successive organization of various banks in small or medium-sized cities with insufficient capital, considering the size of the operation involved. Raising capital funds for the establishment of a new bank by pledging as collateral the stock of an existing bank and repeating the operation as successive new units were established resulted in but little real new outside capital funds being available for the protection of depositors. On the other hand, group banking was the result of the bringing together under unified ownership and coordinated management of a number of strong, long-established banks, with histories going back, in some cases, for fifty or sixty years.

While the member-banks of a group banking system will maintain their several corporate entities, with the management primarily vested in the hands of local directors and officers, exercise of control, as an incident to ownership by the group holding company, naturally

points out and prohibits concentration of risk in the making of loans. Furthermore, in making investments in bonds the group holding companies are in a position to manage the bond-investment portfolios of member-banks more efficiently through the maintenance of a central statistical and investment department. Obviously it is of but little more trouble or expense to direct the investment policies of fifty banks than it is to perform a similar function for a single bank, as many of the issues under scrutiny will ordinarily be found in the portfolios of a large number, if not all, of the member-banks of the group. Hon. John W. Pole, Comptroller of the Currency until a few months ago, summed up this transitional development in his annual report for the year ended June 30, 1929, as follows:

> In the absence of legislation to remedy the conditions above described, private enterprise has, within recent months, undertaken to meet the economic situation presented by the growing isolation of the country banks. Local holding companies have been formed in many sections of the country for the purpose of bringing together a number of banks into a single operating group. The usual procedure is for the holding company, a state corporation, to purchase a majority of the stock of several banks, one of which would be a large city bank, which in effect becomes the parent bank of the group. The management personnel of the central bank becomes in practice the responsible management of the entire group. Through such a group system it appears to be possible to make a close approach to a form of branch banking whereby each operating unit leans for support upon the central bank, or upon the holding company, and receives the benefits of its moral and financial support; its prestige and good-will; its extension of the wider type of banking service; and the benefits of its highly trained management.

Group banking has undoubtedly stood up exceptionally well during a period of difficult banking conditions, and in some sections of the country—notably the Great Northwest—it has done more to promote confidence and stability than any other one factor. However, as Comptroller Pole states:

> If branch banking were permitted to be extended from the adequately capitalized large city banks to the outlying communities within the economic zone of operations of such banks, there would be no logical reason for the existence of the local holding company and it would give way to a system of branches operated directly by the central bank of the group.

TREND TOWARD FEWER AND LARGER BANKS

The unmistakable trend of economic pressure is in the direction of fewer and larger banks. As Mr. Thomas W. Lamont of J. P. Morgan & Company stated on November 18, 1932: "The fact is that, despite the melancholy number of eliminations that have taken place, the country has today far too many banks. Our banking units should on the average be far larger than they are today. The small, ill-capitalized institutions should be merged so as to gain the normal stability, diversity, economy, and management of the larger concerns." Adverse conditions which make it difficult for a vast number of independent unit banks to survive, still prevail and will continue to prevail with possibly increasing intensity. Liquidation and absorption appear to be the only two alternatives. State-wide branch banking offers the fairest means for terminating the independent (?) existence of the smaller unit bank with least loss to the depositors.

Every engineer, and in fact every American citizen, has a vital stake in the solution of this paramount problem. If this more or less informal commentary upon the present banking situation shall in some small measure assist the reader to form an intelligent opinion in the premises, it will have adequately served its purpose.

Ewing Galloway, N. Y.

THE FEDERAL RESERVE BANK IN NEW YORK CITY

Technical Curricula and
LIBERAL EDUCATION

By RAY PALMER BAKER[1]

The applied sciences, if taught with imagination, serve not only as media of thoroughness but also as media of tolerance. In their incidence they touch all classes in the community. Because of this fact the great schools of technology have always been hospitable toward the social sciences. In recent years especially they have set themselves to the task of interpreting the economic bases of society. Increasingly, therefore, they have stressed those studies that are most likely to aid their students in understanding the forces released by the Industrial Revolution and the cataclysmic effects which they have produced. In their sense of proportion these institutions do not need to fear comparison with more conventional colleges.

Upon the element of taste, also, they have been almost as insistent as upon that of tolerance. To literature and the arts they have allotted a considerable place. While maintaining their professional aims, they have cultivated those studies that contribute to thoroughness, tolerance, and taste in the life of the individual and the community. If this be not a liberal education, what is it?

IN A RECENT report President Butler, of Columbia University, in speaking of his plans for the development of a great engineering center on Morningside Heights, referred to the reluctance of educators reared in the older traditions of the academic college to recognize the cultural significance of the technical curricula developed within the last century. Consequently, as he there pointed out, all the earliest schools of engineering arose outside the universities. Not until they had established their usefulness were they admitted to the latter's society. Moreover, in the West especially, many of them have led a pariah-like existence apart from that of their sisters upon the same campus. As a result they have often been stifled culturally and, through the pressure of their environment, reduced to the status of trade schools, concerned principally with the teaching of technique. Even today the colleges of engineering attached to some of the oldest universities in the East are still regarded as foster-children. Under the circumstances, only the technical schools with an independent corporate existence have had an opportunity to develop freely. In view of this fact any consideration of the liberal aspects of the technical curricula now current may well be limited to those maintained by these institutions. What I have to say will therefore apply particularly to them.

The question which I intend to propose for discussion, and which I shall attempt to answer tentatively at this time, is this: Do such technical curricula provide the elements of what is commonly called a liberal education?

Before turning to the arguments which may be advanced in support of such a thesis, we must first divest ourselves of the feeling, held by not a few, that any type of education which is directed toward a specific end is necessarily illiberal. On historic grounds alone, apart altogether from the reasons advanced by contemporary thinkers, such a point of view is open to serious criticism. Those who maintain it forget that higher education in the Western World has always been professional in its purposes.

EARLY DEVELOPMENTS IN OCCIDENTAL EDUCATION

It is surely unnecessary for me to urge at length the soundness of this generalization. Like the other great English foundations, Oxford was established primarily for the education of clerks. No one who has delved into its records is likely to forget the absoluteness with which it long devoted itself to that purpose. Like many of its younger associates, Harvard was also dedicated to the perpetuation of an educated ministry. Properly, therefore, the curricula of Oxford and Harvard were organized to provide a specific training for the cure of souls. The subjects taught—language, history, philosophy, and theology, to name only a few—were regarded primarily as tools, as means to definite and necessary ends.

As the clerks—at first clergymen, statesmen, lawyers, and physicians—began to limit their activities to the church, and to surrender their places in public affairs to members of noble or at least gentle families, the latter sent their sons, especially the cadets, into the universities. For them, as for their predecessors and associates preparing for orders, the colleges in which they proceeded to their degrees were cherished primarily as gymnasia in which they might exercise their powers before exhibiting them upon a larger stage. It was long, indeed, before the ideal of an education valuable for its own sake appeared in England. Ultimately, however,

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Address delivered at a convention of the International Association of Torch Clubs, Albany, N. Y., May 6, 1932.

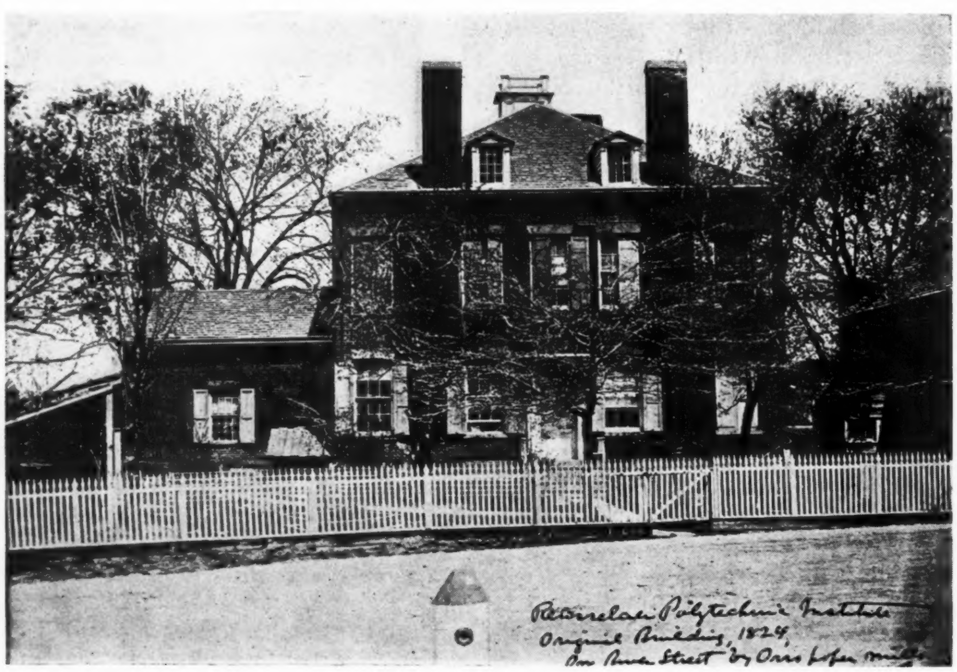
the training—for so it was regarded—organized for those who intended to serve the church or the state became the prerogative of the aristocracy and the gentry, who alone assumed authority over the kingdoms of this world and the next. Hence, through courses which I do not need to follow here, the universities became citadels of privilege, associated with the interests of the ruling classes, which employed them to strengthen their position in the community. Naturally, therefore, these groups established the type of education which they received as part of the equipment of a cultivated gentleman; and in spite of the changes to which I shall refer, it has never lost entirely its social significance.

As the processes of secularization continued in England, law also achieved its independence. Because of its intimate connection with the processes of government, the background of language, history, and philosophy expected of those who occupied positions of public trust seemed also to offer the necessary foundation for the practice of law; and at first, as you are aware, lawyers were merely clerks dedicated to one phase of a larger profession. Although, in Italy and the Low Countries, faculties of law were recognized at an early date, they did not acquire autonomy in English-speaking countries until a much later period. When the law school displaced the old apprentice system, the conception of a liberal education was so deeply rooted that its professional origin had ceased to be apparent. In essence, however, the demands made upon students of law rest upon a distinct utilitarian basis.

The history of medicine has not been dissimilar. Accepted early on the Continent, it was late in securing recognition in England. Indeed, since it required a kind of training different from that considered necessary for the clergyman, the statesman, and the lawyer, the first practitioners were drawn from the lower classes; and as late as the nineteenth century old-fashioned people were inclined to wonder whether a physician, much less a surgeon, could possibly be a gentleman. Even today educators occasionally find it difficult to discover anything of cultural value in the routine of the medical school. Essentially, however, its aura—if I may use the term—does not differ from that of the college oriented toward the needs of the clergyman, the statesman, and the lawyer. I think that you will have to admit that there is at least considerable ground for the assumption that higher education in the Western World has always had a professional bias.

TECHNICAL STUDIES ESSENTIAL IN ANY SCHEME OF HIGHER EDUCATION

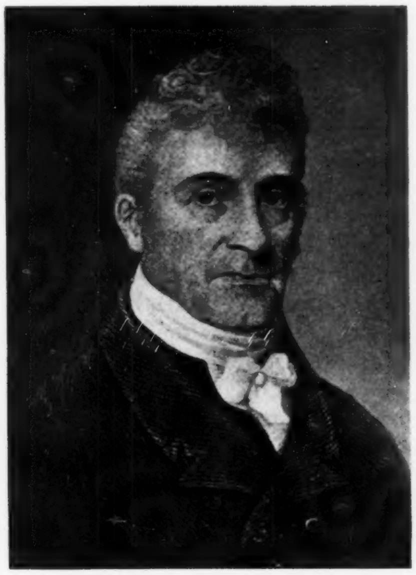
Although I seem to be long in returning to the question which I asked some moments ago—whether the technical curricula now current provide the elements of what is commonly called a liberal education—I do not intend to apologize for the aside. The point that I want to make is that, historically, there is no reason for eliminating the curricula of the engineering school as media of culture simply because they are directed toward specific ends. Indeed, if what I have been saying is grounded on fact, there is good reason to believe that such direction—and this, of course, in the French point of view—is almost essential in any scheme of higher education. Nevertheless, it must be admitted that many of our educators still refuse to accept such a conclusion, and that the question which I have raised can be approached more profitably from another point of view.



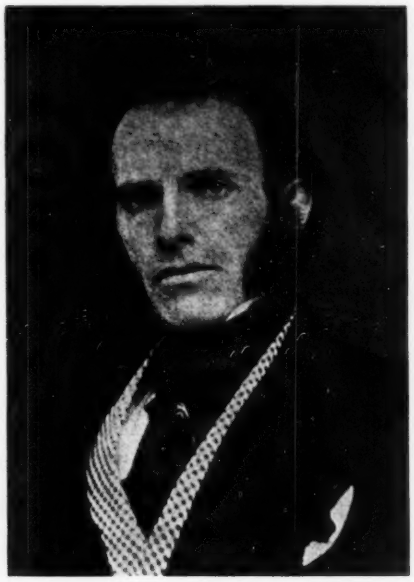
RENSSELAER POLYTECHNIC INSTITUTE—ORIGINAL BUILDING, 1824

I propose, therefore, to examine briefly the content of the curricula maintained by the great schools of technology and to ask how far it is likely to contribute to the development of the qualities that any type of education which is valuable for its own sake should admittedly foster. Some years ago, when I was speaking in this city before the members of another organization, dedicated, like yours, to intellectual pursuits, I hazarded the opinion that these qualities are thoroughness, tolerance, and taste. More specifically, I meant that any type of education that calls itself liberal should cultivate a spirit of accuracy, a re-

AMOS EATON



STEPHEN VAN RENSSELAER



BENJAMIN FRANKLIN GREENE

fusal to accept anything less than the truth; that it should encourage the development of a sense of proportion, an awareness that no problem, whatever its nature, can be approached from a single point of view; and, finally, that it should recognize that in both conduct and art there is an appropriateness, a beauty of adaptation, that is the crown of life. These, gentlemen, are exactly the qualities at which, apart altogether from their professional goals, all technical curricula of the highest type consistently aim.

May I pursue this subject a little further, and, if you will permit me, turn back again to the past for substantiation of what I have been saying. As you doubtless know, Rensselaer Polytechnic Institute is the oldest school of engineering in the English-speaking world, and its influence has been potent among other institutions of its type. It may be worth while, therefore, to consider for a moment the ideals of its founders. You will find them set forth not only in the letters of Stephen Van Rensselaer, but also in the papers of its first academic head, Amos Eaton, who was one of the great figures in the history of American education. The qualities upon which the latter insists are the very ones which I have stressed as characteristic of any scheme of liberal education: thoroughness, tolerance, and taste; and he took issue with the colleges of his day because they did not cultivate these qualities. In its origins, therefore, engineering education was a direct challenge to the academic tradition.

It is interesting to examine the curriculum introduced by Eaton when he assumed direction of the Institute. Although it continued to confer the bachelor's degree in arts, its courses differed radically from those given elsewhere. The most notable departure was the emphasis placed upon the natural sciences and their applications to the common purposes of life. Through them, as he explained, Eaton aimed not only to stimulate intellectual curiosity—lacking then, as now, among most undergraduates—but also to cultivate an instinct for accuracy based upon observation and the principle of learning by doing. Moreover, although he insisted upon the importance of the control over one's environment secured through such discipline, he drew upon the social sciences as well. Since he also included literature and the arts in his scheme, he therefore anticipated in a remarkable manner the tendencies of liberal education during the nineteenth century. When the course in civil engineering emerged, a little later, it was based upon the same principles.

The characteristics of the technical curricula of the present day were fixed, however, not by Amos Eaton but by B. Franklin Greene, whose report, dealing with the reorganization of the Institute in 1850, is the most significant document of its kind. In it also he made the claim that the plan which he advocated was intended to provide not only a foundation for professional practice but also a culture, adapted to the exigencies of the day, that ministered to all the needs of the individual. In short, he maintained that the technical curricula which he outlined fostered the very qualities which I have cited: thoroughness, tolerance, and taste. Under these circumstances, we may well ask ourselves how far his ideals have been realized.

All technical curricula, I do not need to remind you, rest upon a group of subjects that are likely to develop the quality of thoroughness to which I have pointed: mathematics, with a recognized place, even in the oldest universities; the physical sciences—physics, chemistry, geology, and mineralogy; to a lesser extent, the biological sciences; and—the essence of engineering—their applications in various fields of human endeavor. From an educational point of view these studies need no defense. Although it is true that there are many who insist that there can be no transfer of competency, no institution of higher learning proceeds entirely upon such a presumption. At any rate mathematics and the

natural sciences are still regarded as likely to contribute to precision of thought and accuracy of observation.

From another point of view, however, they possess a cultural value of great significance. Only through the natural sciences is it possible for man to master and therefore to appreciate the physical aspects of his environment. Hence even those experts who refuse to recognize the validity of these disciplines in and for themselves do not hesitate to emphasize the importance of their implications. Consequently it is difficult to formulate a definition of higher education that does not include within its boundaries the requirements in the natural sciences demanded by the technical schools of the highest type.

Regarding the educational value of the applied sciences, there is no such unanimity of opinion. Indeed, these are precisely the studies that lead many of those who have been reared in the academic tradition to question the liberality of technical curricula. If I were inclined to beg the question, I might point out that at Rensselaer, as an example, only a little more than one-third of any curriculum is devoted to the subject of concentration. That is, only a little more than one-third of any curriculum is immediately professional. Even with related subjects in engineering, the ratio is still about one-half. I doubt whether any one here would care to argue that such a proportion vitiates the liberality of the larger background which I have been describing. But I do not want to advance in this argument by any such negative procedure. Rather I wish to suggest—for I take it that this is the purpose of this gathering—that just as the natural sciences, valuable in themselves as media of discipline, possess ramifications that are culturally notable, so the applied sciences, valuable in themselves likewise as media of discipline, are rich in inferences that are culturally important. Indeed, I shall go so far as to insist that some contact with these processes is necessary for an understanding and appreciation of contemporary civilization. Many of the difficulties confronting society are obviously due to the fact that the academic tradition has remained ignorant of and exhibited little sympathy with those developments which have been most characteristic of the century. Some acquaintance with the temper of the machine and some insight into the technique of the factory seem today essential in any well-considered scheme of education. It appears inevitable, therefore, that as the natural sciences—welcomed at first by the great technological institutions—have established themselves in the colleges, the applied sciences will eventually find some place at least in their economy.

AMOS EATON HALL AT RENSSELAER (LIBRARY AND AUDITORIUM)

HOSPITALITY OF SCHOOLS OF TECHNOLOGY TOWARD THE SOCIAL SCIENCES

As in the case of the natural sciences, I cherish the applied sciences, if taught with imagination, not only as media of thoroughness but also as media of tolerance. In their incidence they touch all classes in the community. Because of this fact the great schools of technology have always been hospitable toward the social sciences. In recent years especially they have set themselves to the task of interpreting the economic bases of society. Increasingly, therefore, they have stressed those studies that are most likely to aid their students in understanding the forces released by the Industrial Revolution and the cataclysmic effects which they have produced. In their sense of proportion these institutions do not need to fear comparison with more conventional colleges.

Upon the element of taste, also, they have been almost as insistent as upon that of tolerance. To literature and the arts they have allotted a considerable place. If at Rensselaer, for instance, we can point to a group of scholars and teachers in the social sciences which now give it distinction in those fields, we can point to as adequate a representation in literature and the arts allied with architecture. One of the reasons why we have recently established a department in the latter field, with a building of its own, is that it may minister to the instinct for beauty among students in engineering. Not only do we require of undergraduates three courses in economics, dealing with the foundations of society, but in addition to the courses developed by the Department of English that interpret the spirit of the modern world, we provide an introduction to the principles of taste through studies that bear directly upon their interests. In a large measure, therefore, Rensselaer—and I take it as representative of other institutions of its type—has achieved the ideals set forth by Greene in his epoch-making report. While maintaining its professional aims, it has cultivated those studies that contribute to thoroughness, tolerance, and taste in the life of the individual and the community. If this be not a liberal education, what is it?

The Economic and Social EFFECTS OF URBANIZATION

By ARTHUR L. POLLARD[1]

The crust of this planet has done very well by the human race. It can do still better. It, with our industrial system, can provide houses that a little while ago would have delighted kings; with foods that Nebuchadrezzar at his feasts could not have imagined. For the romantic it can even provide means to fly, and for the practical it can provide all the gadgets that any human heart could desire. It can provide all of these things in great abundance and to all of us. But it cannot now provide, nor in the nature of things can it ever provide, any such mystic and fantastic financial security as we dreamed of in the years before 1929.

ALMOST every one asks: "Why, with all our boasted economic knowledge, our vast statistical organization, and our forecasting wizards, have we not long ago found the cause of depressions and done something to cure them?" The answer is simple: it is that the task of reasoning from a known effect back to an unknown cause is always difficult, if not impossible. We try to do it in two ways. We either trace the effect to probable causes and decide among them from our general experience, or we find in history a series of causes and effects, which may fall into a pattern, so that we can identify our effect in the general process of history.

Today there are certain effects that alarm and dismay us. We have tried to reason back to primary causes, but without success. The historical method helps a little, but even here the primary cause is so remote that we cannot find it. Even if by some chance we should find it, probably few would agree with us. There is so much difference of opinion and so much confusion that the author suspects the cause is not in the realm of economics at all. It may lie in the nature of our acquisitive instincts, and men never have had much success in reasoning about such things.

SOCIAL EFFECTS OF UNEMPLOYMENT

The immediate effect which we shall consider is unemployment with its attendant train of dependence and pauperization. Referring to Fig. 1, the upper curve shows the total number of unemployed and their dependents. This started from a rather high level, for prosperous times, and has continually increased since 1929. There are now close to 25,000,000 persons without any regular means of support. This estimate is based on the *Annalist* employment index and the assumption of somewhat less than the normal number of dependents for each unemployed worker. Fortunately the rapid increase seems to be checked, and there are many signs of local improvement. On the other hand, the tendency of the unemployed to become dependent upon public or private charity, as shown by the lower curve, is still an increasing one. Those of the unemployed who have not yet become dependent upon charity are living by means of casual jobs, or on their savings, or are being supported by relatives. Obviously such sources of sustenance are impermanent and are subject to rapid exhaustion. An estimate made by the author and based on sample cities shows that the number of destitute may easily reach 15,000,000 during the coming winter.

The effect upon character of such a condition of affairs has been amply commented on and needs no discussion here, but it may be interesting to consider the implications of a similar condition in ancient history. Caius Gracchus, late in the 2d century B.C., found a similar situation. He attempted to ameliorate it by building public works and by selling grain at less than the market price. A few years later grain was sold at a fraction of its market price, and still a little later, grain, wine, and oil were distributed free. From then on the level of public support constantly went up and wages constantly went down, until there was very little incentive to work. One hundred years after Gracchus there were 300,000 persons receiving public support in Rome, and hundreds of thousands in the other cities of the empire. For some four hundred years after this mobs comprising from 5 to 15 per cent of the population were fed by the various Roman municipalities. The temporary measures of Gracchus became permanent and extended over a period three times the length of that from President Washington to President Hoover. The

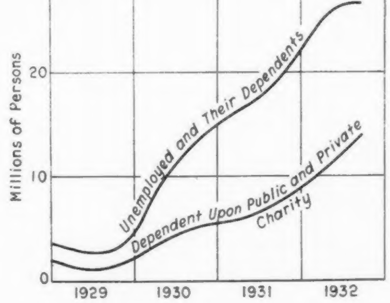


FIG. 1 GROWTH OF UNEMPLOYMENT SINCE 1929

[1] Manufacturers' Representative, Knoxville, Tenn.
Presented at a meeting of the Knoxville Section of the A.S.M.E., Knoxville, Tenn., October 21, 1932.

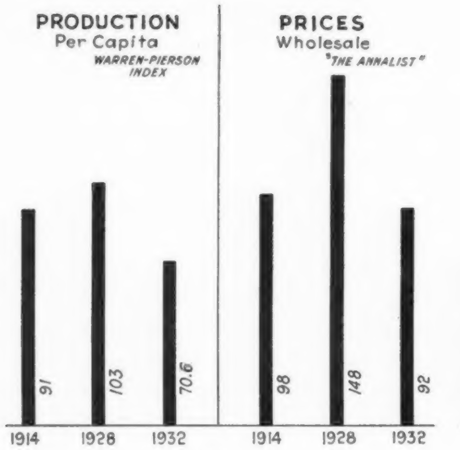


Fig. 2

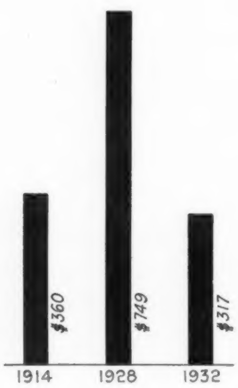


Fig. 3

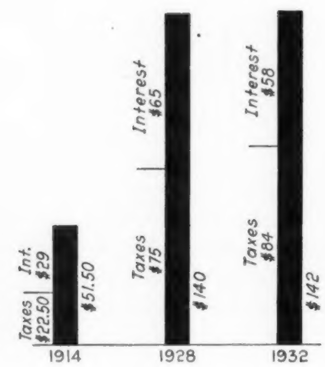


Fig. 4

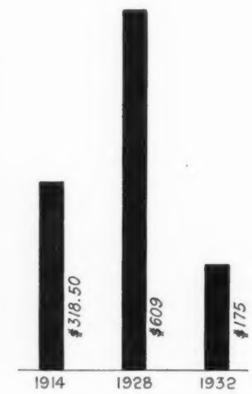


Fig. 5

FIG. 2 FACTORS ENTERING INTO THE PER CAPITA MONEY INCOME

FIG. 3 PER CAPITA INCOME IN DOLLARS
(1914 and 1928 from King's estimates; 1932, projected from *Business Week's* estimate.)

FIG. 4 TAXES PLUS INTEREST PER CAPITA
(Interest on Goverment loans not included.)

FIG. 5 PER CAPITA INCOME OF ABOUT TWO-THIRDS OF THE POPULATION AFTER INTEREST AND TAXES HAVE BEEN PAID

Roman mobs developed a political philosophy, the professional viewpoint, and a canny appreciation of how to get the most out of the state. If history teaches anything, it teaches that conditions such as these are not corrected by drifting. There is nothing inherent in civilization that corrects them.

INDIVIDUAL INCOMES—TAXES—INTEREST

Passing from the social effects to the immediate economic causes, which are in themselves effects, we come naturally to the income of the individual. The entire economic effect of the depression is measured by the level of individual incomes and the way in which it is distributed.

Fig. 2 shows the two factors entering into the per capita money income. On the left the physical volume of production is compared for three typical periods. This is the Warren and Pearson index of actual production in terms of bushels of grain, pairs of shoes, tons of steel, etc., but independent of the money value. This is, in fact, the real income of the country. If all trade were by barter there would be no other way to represent it. In 1914 this index was 91, in 1928, 103, and in 1932, 70.6. A decrease of 31 per cent in the actual consumption of goods is, of course, of considerable importance, but would not be at all disastrous if it affected every one alike. With 69 per cent of our 1928 consumption today, we are still better off than any other country in the world. The reason that this drop does not affect all alike lies largely in the influence of the price level. On the right is shown the level of wholesale prices for the same periods. The variation here is greater, but of the same general nature.

What the author attempted to do was to find an index which would make it possible to estimate the current level of national income from month to month. By multiplying the above-mentioned two factors together a new index was obtained which serves this purpose with very fair accuracy, provided no great change in the distribution of population has taken place over the periods being considered.

Estimates of income for 1914, 1928, and 1932, in dollars per capita, are given in Fig. 3. The estimate for 1932 was obtained by applying the index just described to the *Business Week's* estimate for 1931. The interesting thing shown by this chart is that our per capita income is less now than it was in 1914, and less than one-half that of 1928. Out of this dollar income two classes of payments are made: those which vary with the price level, and those which are fixed. If all items varied with the price level, the goods and services commanded would vary only with the physical volume of production. But then, if all payments were of this kind, there would probably not be any depression and we should not need to worry about it. The fixed items are for the most part taxes and interest. The fact that they do not vary and that they are so high is what makes this depression so severe and so insoluble. It is apparent that their proportional effect is enormously greater on a low level of national income than on a high one.

Fig. 4 shows taxes and interest for the periods considered. The interest figure does not include interest on Government obligations, so that actually about 20 per cent of the tax item should be, properly, interest and sinking-fund payments. Very little comment is necessary on these figures. They are a matter of general knowledge and concern, but it is not generally realized that they are higher for 1932 than for 1928, and that for both of these years they are nearly three times the 1914 level.

A chart that requires considerable explanation and some apology is shown in Fig. 5. It indicates in a very general way the condition of approximately two-thirds

of the population who pay taxes and interest but receive no direct money benefit from them. Every one with any income at all pays taxes and interest in some form. So it has been assumed that these payments can be deducted from the per capita income. Further, it has been assumed that one-third of the population receive all of these payments. On this assumption the per capita income remaining in 1914 was $318.50. In 1928 it was $609, while in 1932 it is $175. This seems startling enough, and it will probably be questioned that two-thirds of the population are so badly off. Certainly the assumption that the one-third receiving taxes and interest are so much better off would be questioned. Let us therefore analyze these two groups further.

The two-thirds who do not benefit are not necessarily the two-thirds receiving the lowest incomes. Many wealthy persons have no income at all today, and in fact, are sustaining enormous losses every year. There are many farmers and merchants who were quite prosperous a few years ago, but who can now live only by letting their taxes and interest go unpaid. There are numerous other groups, including the unemployed, who do not have as much as $175 a year.

As for the one-third who should be so well off, the idea that they must be prosperous arises from a general misconception of the nature of modern credit as something that necessarily must be passed from hand to hand. Modern credit is, of course, nothing of the sort. It is merely an entry in a book, and probably every dollar received as interest during the last few years has, generally speaking, been used in writing off losses from other sources. Nevertheless there are a few whose condition is certainly better than ever before. For example, the purchasing power of the salary of a United States senator is greater than at any time in our history, and this is true of the salaries of most federal and many state and municipal employees.

The author is not defending the accuracy of these figures for any particular two-thirds of the population, because he realizes that there is no such sample population. But he does believe that nearly this fraction of our people find themselves actually unable to buy more than 60 per cent as much as they did in 1914, which is just what the figures indicate. Here, by the step-to-step reasoning first mentioned, we get back to the social effects. It is easy enough to see that 60 per cent purchasing power for two-thirds of the population, in a nation organized for around 100 per cent purchasing power, would cause just the social phenomena that we have observed. The three significant things are the high taxes, the burden of debt, and the increasing pauperization. All of these have prevailed in every period of social upheaval. They were the outstanding characteristics of the Babylon of Nabonidus, the Rome of Gracchus, of the Antonines, and of Diocletian, the Russia of Gudenof, and the France of Louis XIV, and they are outstanding in the Europe of 1932.

These historical correspondences have a bearing on many of the ideas current today. Technological unemployment may be important in this depression, but it could have had nothing to do with those other great periods of depression. Nor has technological unemployment much other historical justification, since the greatest technical improvement of all time was the steam railroad, and we passed through the railroad-building period without great disaster.

So far the author has discussed rather simple relations between social effects and economic causes. It is when we leave the simple and obvious conclusions from experience that we enter the *terra incognita* of economics. Here, as Dr. Warren remarks, the situation is much the same as in medicine during the great plague of the middle ages. Then, the plague was blamed on sin, political chicanery, or witchcraft. It was not until 400 years later that Pasteur made the discovery that led to the real cause. It is hard to believe that we now know as little of economics as we did of medicine in the middle ages, but many are beginning to think this.

THE URBANIZATION PROCESS

The next step, that of considering more inclusive causes, leads us immediately into the difficulty of making a selection. Literally hundreds of these have been proposed. From this mass of data and opinion the author has selected just three that seem important to him. Only those causes have been chosen for which it is possible to find historical correspondences, and strangely enough, all three seem to be intimately related—so much so, in fact, that it is almost impossible to consider one without the others. These three are the urbanization process, the debt process, and what might be called the monetary lag. The first two are sufficiently descriptive. The last has to do with the tendency of the supply of the monetary base metal to lag behind the growth in trade at certain times. Because of time and space limitations, but one of these can be considered here, namely, the urbanization process.

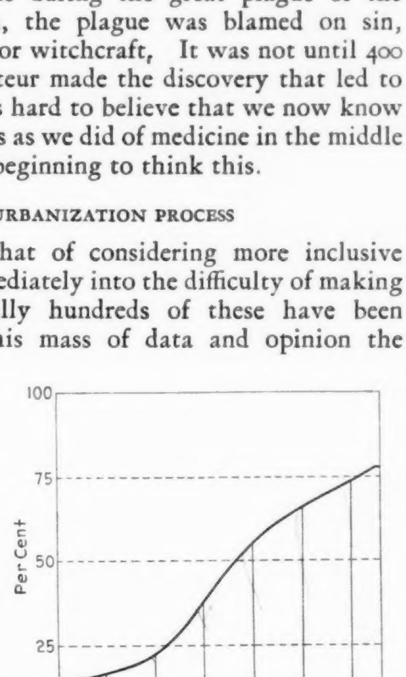


FIG. 6 URBANIZATION IN THE UNITED STATES—PERCENTAGE OF POPULATION NOT ON FARMS

Fig. 6 shows the progress of urbanization in the United States since the beginning of the 19th century. This matter, the author believes, has received far less attention than it deserves. As a matter of merely general interest, it is probably the most astonishing and far-reaching population movement that has ever taken place. As an economic unit we are today the most completely urbanized people in the history of the world. There are, of course, some small trading nations that are fully as urban, but they are not economic units, and when the agricultural hinterlands that serve them

are taken into account, they are not so urbanized as ourselves.

The figures used in preparing Fig. 6 are those of the Department of Agriculture showing the population not living on farms. There are some other sets of figures

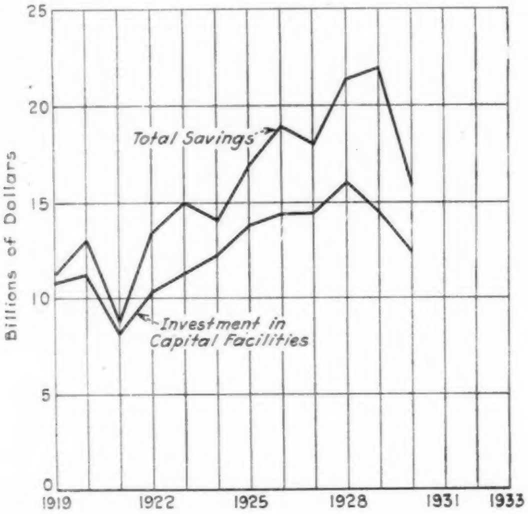


FIG. 7 MONEY SAVED AND INVESTED ANNUALLY
[Total savings, 1920–1930, $177,600,000,000; total investment in same period, $138,600,000,000 (*Business Week* figures).]

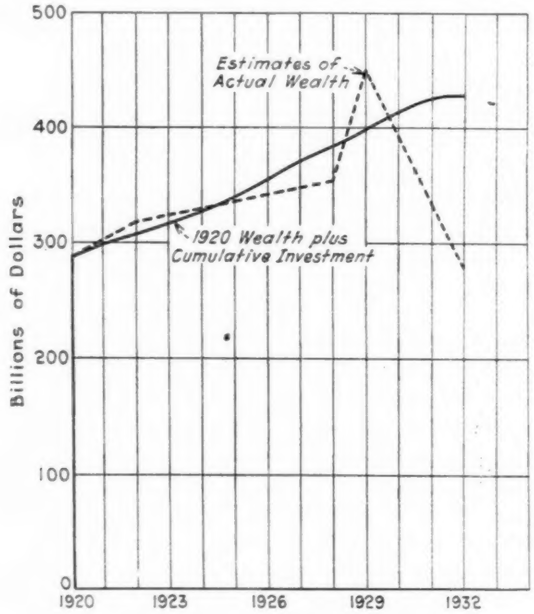


FIG. 8 WHAT BECOMES OF SAVINGS

based on cities of a certain size, but those mentioned have been used for a very definite reason, namely, one that has to do with a fundamental difference in outlook in respect to money and security. The man who does not live on a farm must in general have money every day to live, while the man on a farm can go for days and sometimes weeks without money. In the past he has needed money only for a very few days in the year.

Back in 1800 only 15 per cent of the population did not live on farms. The great majority then did not need to save much money in the form of cash or liquid credits, but saved it rather in the form of land and equipment. Today 77 per cent do not live on farms. The only security that this city population can have must be provided largely in the form of cash or liquid credits. The difference is enormous, and it has a bearing on our social and financial organization that has scarcely been appreciated, and certainly has received far too little attention.

Let us analyze the difference in outlook more thoroughly. To do this we must consider a more typical and experienced agrarian population, since our own has been corrupted by the prevailing investment illusions of the cities. The French farmer, for example, has been taught the reality of his security, and the mutability of everything else, through centuries of experience. He, traditionally, has a horror of debt amounting almost to an obsession. He farms primarily to maintain himself and his family, after which he farms for enough money to pay taxes and to buy the few things that he cannot obtain by barter. Commonly he has a little money left over which he invests in bonds, usually government bonds. There are not enough mortgages in France to satisfy this demand, because no one mortgages anything except in case of dire necessity. He has always lost his savings sooner or later, but this has never affected the real security of his farm. French farmers today are far more secure than kings or utility magnates. In the south of France there is a farm that has been in the same family for 1100 years. If, 11 centuries ago, it had been sold and the money invested in something else, it would have been lost 20 times since the original sale through changing ownership.

THE URBAN DEMAND FOR FINANCIAL SECURITY

Turn now to our own typical city man. He is usually working for a wage or salary. Commonly he does not even have a garden, and often he moves his few pieces of furniture from cell to cell in our great city apartments. He has no real security in things that he himself owns and controls. He must provide for the days of sickness and old age through the investment system, where vast aggregations of capital are managed by beings more remote than the high priests of antiquity. It does not matter whether society needs the factories and equipment that his money builds. That constant pressure to create values which will satisfy the urban demand for security leads us to create and value things that intrinsically have no more utility than the pyramids of Gizeh. Because of this demand rather than because of a real need we have overbuilt most of our productive equipment from 50 to 100 per cent.

This is a point that should be amplified, but it is not quite clear how it should be done. The entire money system is so much a part of our thinking that it is difficult for any of us to step outside of it. Money was devised to facilitate the exchange of goods and not to provide security. Purely as a medium of exchange it works perfectly. As a means of providing security it

has failed miserably, not only now, but at more or less regular intervals during the last four milleniums. In desperation Sparta tried to do away with it, and during four centuries of the middle ages it almost passed out of existence. But it has always come back, and we shall have to get along with it and make it work if we can. If we did not have money it would be difficult to imagine, say, carpenters collecting hammers and saws beyond their possible future needs under the delusion that such things would give them security in their old age. Shoemakers certainly would not collect lasts and stitching machines for such a purpose. Nor would society generally collect machines and buildings. Yet that is exactly what the money system causes society, particularly urban society, to do. As a nation we go without shoes in order that we may build shoe factories! We go without all things in order that we may build factories to make them; and the more useless factories that we build the less are we able to consume their products. Every dollar that goes into useless capital facilities is a dollar taken from consumption, while consumption dollars are the only things that make facilities of any value. This has been called the dilemma of capitalism. It is not that really; it is merely the dilemma of men who try to obtain a type of security that does not exist on this earth. It is because of this that we have the cry for planned production. But the planned-productionists have never dared to expose the ultimate implications of their system. If we have planned production we shall have to control investment in capital facilities, and if we do that we shall have to limit savings, forcing the money into consumption.

Unreal savings are always lost eventually, but they are often lost by the wrong people. During the last 12 years we, in the United States, have saved and invested in new capital facilities about 140 billions of dollars (Figs. 7 and 8). The depression has wiped out about 150 billions of dollars in values, or 10 billions more than we saved in 12 years. We still have the buildings, machinery, and improvements, but we do not have the money values. This is also an age-old process. History records no period of over a few years when it has not been necessary to wipe out values, either by war, revolution, inflation, or bankruptcy. Men can save for many years such things as houses, crockery, or canned food; misers can save precious metals; but no one can save for long the thing that we know as money.

THE DEBT PROCESS

The demand of urban populations for security has a bearing also on the debt process. Roughly, the debt process is the tendency of debt to increase faster than wealth. Part of the city man's savings are invested in evidences of ownership, in factories and buildings directly. But largely they are invested in evidences of debt, in bonds and mortgages, or, indirectly, in bank deposits and insurance policies. What is one man's savings becomes another man's debt. The more that is saved per capita, the more debt there is per capita. Debt grows just a little faster than wealth, until eventually the weight of debt becomes insupportable. There is a rush to liquidate, and the ensuing collapse of values leaves debt actually greater than the going value of all wealth. Just this happened in England. Only last year a prominent English economist estimated that the sum total of the outstanding debts in England exceeded the value of all its wealth.

There are other results of the urbanization process, affecting enormous industries and millions of people. For years we have been adjusted to rapidly growing cities. The subdivision business, the quantity building business, the paving business, and the cast-iron pipe business depend upon the rate of growth being maintained rather than upon the actual level of urbanization. If our urbanization has reached a climax, as seems quite possible, then these industries must adjust themselves to a condition that they have never known before. However, this need not alarm us. Men have always had to adjust themselves to changing conditions. But we are men rather than bees or termites. If we cannot build in quantity we can tear our cities down and rebuild them on a quality basis. Already old and obsolete buildings are being torn down to destroy values and save taxes. Sooner or later enough of them will be torn down so that we can start rebuilding on a quality basis. It is merely a slowly changing mental conception that stands in the way: a conception of values that invests any building, however worthless, with a theoretical earning power.

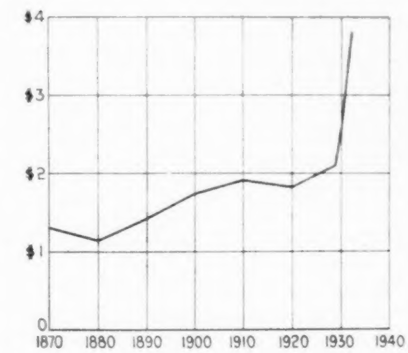


FIG. 9 DOLLARS OF TOTAL DEBT PER DOLLAR OF INCOME
(Rough estimate based on bank credit.)

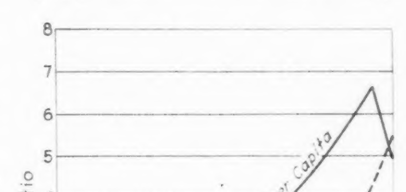


FIG. 10 THE IDEALIZED DEBT PROCESS AS EXHIBITED IN THE HISTORY OF ALL COMMERCIAL NATIONS

How to provide real security for an urban population such as ours is probably the most difficult problem that civilization faces. There are real types of security. There is, for example, the possibility of many city men owning small farms which they can control and work in hours not taken by work in the city. How many this might provide for is conjectural. But there is

(Continued on page 60)

An Analysis of CHIMNEY-DRAFT EQUATIONS

By JULIAN C. SMALLWOOD[1]

ALTHOUGH much has been written in recent years upon the economical proportioning of chimneys, methods of design have by no means advanced to exactitude either quantitatively or theoretically. During the past twenty years, specialists on this subject have perhaps unduly emphasized its strictly mathematical aspects, and devoted too little attention to the accuracy of fundamental data and to the results of numerous experiments made in that time. It is the purpose here to show how the magnitude of these data affects design procedure, and to indicate the need of further research.

The modern boiler setting is so high as to constitute in itself a chimney of no mean proportions. The column of very high-temperature gas contained therein furnishes a draft which partly overcomes the resistance to flow through the boiler and gives the gas a certain velocity at the last pass. This draft may or may not be augmented by a forced-draft fan. Whatever means are employed for producing mechanical draft, it remains for the chimney to effect an additional draft, at the level where the breeching enters, to dispose of the furnace gas at the required velocity. As this discussion deals exclusively with the chimney, it is assumed that the required draft at this level is known.

In this paper the term "effective draft" means the pressure difference between atmosphere and chimney gas under conditions of flow, as indicated by a manometer connected at the base of the chimney, or level where breeching enters. By "static draft" is meant the pressure difference due to the difference in weight per unit area of the air column outside and the gas column inside the chimney, each of the height of the chimney. "Friction draft" means the pressure corresponding to the frictional resistance to flow in the chimney. Finally, the draft required to increase velocity is called the "velocity draft."

The following notation is used:

- H = height, in feet, of chimney above base
- D = diameter, in feet, of chimney. Only round sections considered
- h, h', h'', h''' = effective, static, friction, and velocity drafts, respectively, inches of water
- p = barometric pressure, inches of mercury, locality of chimney
- w, w' = density of air and chimney gas, respectively, lb per cu ft, at 29.92 in. Hg and 32 F
- W = rate of flow of chimney gas, lb per sec
- T, T' = average absolute temperature, deg F, air and chimney gas, respectively
- w'' = density of chimney gas, lb per cu ft, at prevailing pressure p and temperature T'
- f = coefficient of friction in the Fanning equation
- V, V_1, V_2 = velocity of chimney gas, ft per sec, the subscripts applying if there is an increase of velocity
- z = viscosity of chimney gas, centipoises
- μ = viscosity of air or chimney gas in English units corresponding to centipoises, lb/sec × ft

The effective draft is the static draft less the draft required to overcome chimney friction, that is,

$$h = h' - h'' \quad [1]$$

One form of the equation for static draft, the general derivation of which may be found in elementary treatises, follows:

$$h' = 3.16\,Hp\left(\frac{w}{T} - \frac{w'}{T'}\right) \quad [2]$$

The friction draft is generally taken to satisfy the Fanning equation:

$$h'' = 0.192\,f\,\frac{V^2}{64.4}\,\frac{4}{D}\,w''H \quad [3]$$

In this, $4/D$ is the reciprocal of the hydraulic radius of a circular section, and the factor 0.192 converts the units of the right-hand side of the equation from pounds per square foot to inches of water.

Equations [1], [2], and [3] are fundamental ones for the height of chimney for a required effective draft. Combining them,

$$H = h \div \left\{3.16\,p\left(\frac{w}{T} - \frac{w'}{T'}\right) - 0.012\,f\,\frac{V^2}{D}\,w''\right\} \quad [4]$$

The flow equation, $W = Vw''\pi D^2/4$, furnishes the relation for diameter:

$$D = 1.13\sqrt{\frac{W}{Vw''}} = 1.13\sqrt{\frac{W}{Vw'} \times \frac{T'}{492}} \quad [5]$$

In Equations [4] and [5], values may be assigned to all of the quantities symbolized except H, D, and V. By assuming values of V, various combinations of H and D may be found from the solution of the equations. This leads to the question, What is the "economical velocity"? A. L. Menzin, in a comprehensive paper,[2] tabulated estimates of this quantity, but did not explain how he arrived at them. In an elaborate exposition of the subject,[3] Alfred Cotton suggested the criterion that the most economical structure to build is one yielding a minimum value of height times diameter. This criterion has been adopted by the A.S.H.V.E. in its annual "Guide" in the chapter on Draft and Chimneys. The treatment there, which is the same as that published by J. C. Mingle,[4] goes a step further than did Cotton: by a process of differentiation

[1] Associate Professor of Mechanical Engineering, Johns Hopkins University, Baltimore, Md. Mem. A.S.M.E.

[2] "Proportioning Chimneys on a Gas Basis," Trans. A.S.M.E., vol. 37 (1915), p. 1065.

[3] "The Determination of Chimney Sizes," Mechanical Engineering, September, 1923, p. 531.

[4] "Selection of Economical Chimney Sizes," *Steam-Plant Engineering*, July and Aug., 1932.

an equation for velocity is evolved corresponding to the minimum value, $H \times D$, to produce the effective draft h. This is called the "economical velocity."

Examination of Equation [4] discloses that the quantities, density divided by temperature, appear as a difference, and therefore a small error in either w/T or w'/T' may cause a large error in H, particularly at low values of T' which make the two quotients more nearly equal. Also the denominator of the right-hand member of Equation [4] consists of the difference of two quantities, the smaller of which depends essentially upon a correct evaluation of the coefficient of friction f. Let us first consider f and Equation [3] in which it appears.

There are no thorough experimental data on the coefficient of friction for flow of gases in chimneys. Menzin,[2] in 1915, used the results of very old, crude, and limited experiments made independently by Peclet and Gale. Each of these experimenters announced a single value of the coefficient, but Gale's value was just double that of Peclet. Menzin's estimate was part way between the two. Menzin and other investigators following him ignored the fact that f is not a constant as demonstrated by many experiments upon the flow of fluids in pipes. In his paper, he combined f with other factors of the Fanning equation [3]; the corresponding value of f he recommended was 0.0162. Following him, Cotton[3] applied the same estimate, and later the "A.S.H.V.E. Guide" adopted it. It is curious that this estimate has prevailed, despite the results of various investigations[5,6] since 1915 showing that frictional resistance is much smaller than that indicated by the Fanning equation with $f = 0.0162$. These investigations, particularly those of the N.E.L.A., which covered a number of power plants, disclosed that the friction was so small that it could not be accurately determined by transposed Equation [1], $h'' = h' - h$, which states that the friction draft is the difference between the static and effective drafts. In more than half of the tests made, h was greater than h', giving the paradoxical result of negative friction and indicating that the errors of measurement or of calculation, or both, were too great for a precise determination.

The problem of frictional resistance to flow of fluids such as oil, natural gas, etc., in relatively small-diameter conduits has been solved[7] by the use of the "Reynolds number." By definition, this is equal to

$$\frac{DVw''}{\mu}$$

the notation being as given at the beginning of this article. This quantity is a pure number and therefore has the same value whether English or metric units are employed in its computation. The principle involved in its application is that the coefficient of friction f for any conditions of flow, regardless of the medium, is the same for the same Reynolds number. It is a function of inside conduit wall roughness only for relatively small diameters; for large diameters the coefficient of friction is independent of the condition of the containing surface. When the friction coefficient is plotted against the Reynolds number on logarithmic coordinates, a curve such as that in Fig. 1 results. As given here, it is for values above the "critical velocity," that is, the velocity at which the flow changes from laminar to turbulent, corresponding to a Reynolds number of about 2500.

There seems to be no reason why the principle of the Reynolds number should not be applied to the flow of gas in chimneys. The velocities are well above the critical because of large diameters and small viscosities, as compared with liquid pipe lines. It may be difficult to estimate accurately the viscosity of chimney gas because, even though this property of most pure gases has been determined, for mixtures it is not readily calculable, nor is the law of variation with temperature well established. Contrary to the case of liquids, the viscosity of gases increases with temperature. A relation[8] giving the viscosity of air as influenced by temperature follows:

$$z = \frac{0.001418\ \sqrt{T''}}{1 + 102.5/T''} \qquad [6]$$

In this, T'' is degrees centigrade absolute, and z is in centipoises. To convert into English units of viscosity, we have

$$\mu = 0.000672\ z \qquad [7]$$

For the sake of arriving at definite results, it is assumed that

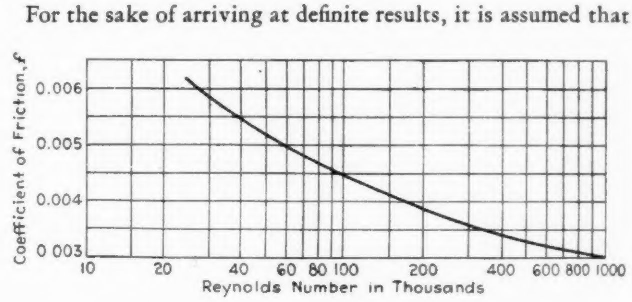


FIG. 1 COEFFICIENT OF FRICTION VS. REYNOLDS NUMBER

the viscosity of chimney gas, in magnitude and variation with temperature, is the same as that of air. The Reynolds number and corresponding value of f may then be estimated for any conditions of chimney-gas flow. It is likely that this procedure will yield a better result, and certainly one more consistent with recent experimental data, than the values of f suggested by Peclet, Gale, Menzin, *et al.*

The value of f as indicated by the Reynolds number is about one-fifth that conventionally used. Its range is between 0.0030 and 0.0035, corresponding to Reynolds numbers of from 1,000,000 to 350,000, instead of 0.0162 as estimated by Menzin. The effect of this change of magnitude upon the friction draft (Equation [3]) and upon the calculated chimney height for a required effective draft (Equation [4]), as well as upon the economical velocity, is enormous. This is best illustrated by a definite example.

It is desired to find the height and diameter to produce an effective draft of one inch of water when the chimney gas is at four different velocities, namely, 20, 30, 40, and 50 ft per sec. For the sake of comparison and further analysis, two sets of results will be found: the first, for a gas temperature of 500 F; the second for 350 F. Other conditions are: Maximum rate of gas flow, 100 lb per sec; barometric pressure, 29.92 in. Hg; $w = 0.0806$; $w' = 0.0840$; temperature of air, 62 F.

The first step is to determine the diameter from Equation [5]. The viscosity is then estimated from Equations [6] and [7], and from it the Reynolds number DVw''/μ, after substituting for w'' its value $492w'/T'$. Next f is found from the curve, and

[5] "Investigation of Chimney Draft," J. C. Smallwood, *Power*, Sept. 16, 1919.

[6] N.E.L.A. tests at New Bedford Gas and Edison Light Co., 1924, and Prime Movers Committee Paper No. 24-3, 1924. Test at Cornell Univ., 1932.

[7] Wilson, McAdams, and Seltzer, *Jl. Ind. Eng. Chem.*, vol. 14, no. 2.

[8] Grindley and Gibson, Proc. Roy. Soc., 1908.

TABLE 1 CALCULATED DATA FOR CHIMNEY GAS AT 500 F

(1) V	20	30	40	50
(2) D	12.15	9.92	8.60	7.70
(3) Reynolds number	568,000	695,000	804,000	900,000
(4) f	0.0033	0.0032	0.0031	0.0030
(5) H	160	162	166	172
(6) $H \times D$	1950	1610	1420	1320
(7) H for $f = 0.0162$	166	179	208	278
(8) h'''	0.0	0.064	0.1531	0.2681

TABLE 2 CALCULATED DATA FOR CHIMNEY GAS AT 350 F

(1) V	20	30	40	50
(2) D	11.17	9.13	7.90	7.06
(3) Reynolds number	690,000	845,000	976,000	1,090,000
(4) f	0.0032	0.0031	0.0030	0.0030
(5) H	211	216	226	241
(6) $H \times D$	2350	1970	1780	1700
(7) H for $f = 0.0162$	230	261	356	760
(8) h'''	0.0	0.076	0.183	0.319

this completes the data necessary to a solution of [4], for height.

Tables 1 and 2 present the results and some of the data for the four velocities and two gas temperatures. On lines (6) are given the products of height and diameter. The seventh line of each table gives the calculated height when $f = 0.0162$ is inserted in Equation [4] instead of f as listed on lines (4). The eighth line shows the velocity draft, to be discussed later.

The effect of the magnitude of f upon the calculated height is immediately apparent, especially at the lower chimney-gas temperature. The product HD does not reach a minimum at a velocity of 50 ft per sec. Further calculation applied to the data of Table 1 shows a minimum HD at a so-called economical velocity of about 67 ft per sec. If $f = 0.0162$ is used, the economical velocity is about 35 ft per sec.

Assuming for the moment that the principle of minimum HD as here calculated is correct, even for low values of f, the question remains: How are the resulting high values of economical velocity to be obtained? The draft required to accelerate the chimney gas from V_1 to V_2 is

$$h''' = 0.192\, w'' \frac{V_2^2 - V_1^2}{64.4}$$

Taking $V_1 = 20$, the corresponding velocity drafts are listed on lines (8) of the tables. Above 30 ft per sec these values are prohibitively high as compared with the effective draft of one inch for which the data are calculated; that is, if the velocity draft is to be produced by additional chimney height.

The calculations at 350 F vary widely with the composition of the chimney gas. The value $w' = 0.084$ was assumed on the basis of no steam in the products of combustion, 12 per cent CO_2, 6 per cent O_2, and 82 per cent N_2. The effect of fuels high in hydrogen, producing water of combustion, is to decrease w' appreciably and increase the static draft. If there is 5 per cent of steam by volume, based on the dry products, w' becomes 0.0825, and if there is 10 per cent, w' is 0.0810. A reduction of 0.003 in w' increases the static draft 7 per cent and decreases the calculated height slightly more than this, depending upon the magnitude of h''.

Of greater importance is the average temperature T' of the chimney gas. Various experiments made since 1911 to determine this quantity disclose that the temperature falls rapidly as the gas ascends. Cotton made a summary[3] of the results of these experiments and pointed out that this fall could not be accounted for only by heat transfer through the chimney walls, and he concluded it was largely due to air infiltration. He deduced from the available data a series of factors wherewith to multiply the entering temperature in order to estimate the average temperature. The author believes Cotton's factors are altogether too low, and that actual average temperatures are very nearly equal to entering temperatures, *provided* that there is no air infiltration. On the assumption that heat is transferred only through the chimney wall, whether it be metal or masonry, and not to raise the temperature of in-leaking air, the temperature fall as calculated from the known laws and coefficients of heat transfer is insignificant.

From the analysis presented here it appears that further experimentation is needed along the following lines: confirmation of the coefficient of friction by the Reynolds number as applied to this problem and a determination of the viscosity of chimney gas; second, air infiltration in existing installations and materials, and means to prevent it; and, third, determinations of effective draft actually required by typical boiler furnaces and auxiliaries, which at present are nearly as much of a guess as are height and diameter.

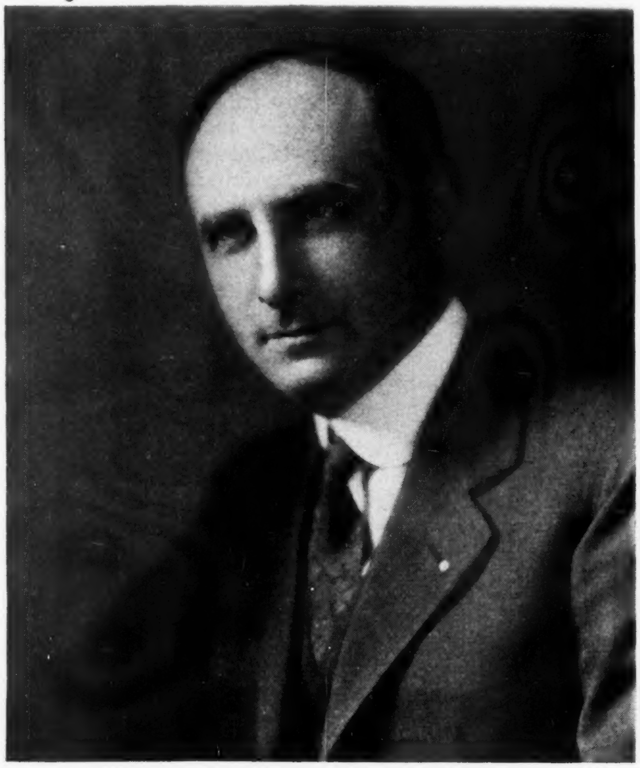
Ewing Galloway, N. Y.

THE A.S.M.E. ANNUAL MEETING

Gathering Marked by Larger Attendance Than in 1931—Economics and Technology Predominate in Well-Planned Program

FROM a multitude of impressions received during the week of December 5, when members of The American Society of Mechanical Engineers assembled in New York for the fifty-third annual meeting of the Society, there persists one of faith in the continued development of the engineering profession in spite of the severe economic shocks to which it has been exposed. Such an important advance as the organization of the Engineers' Council for Professional Development, in which the Society was one of the leading proponents, was especially noted by President Lauer in his address, to be found elsewhere in this issue. Without doubt the formation of this Council will be remembered as the outstanding event of President Lauer's administration; and long after the destructive forces of the business depression shall have ceased to haunt men's minds, engineers will have daily reminders of the constructive forces that initiated the Council and laid down the program of its activities. Furthermore, as President Lauer pointed out to the members of the Society in his valedictory letter that appeared in the December 7 issue of the *A.S.M.E. News*, present conditions offer opportunities for a purging of our institutions of unimportant and useless activities, for a reaffirmation of faith in desired objectives, and for a rededication of loyalties to institutions that have proved their worth. Evidences of the disposition to seize these opportunities and make the best of them were abundant at the meeting. And last, though by no means least, the program of the meeting gave convincing proof that the progress of knowledge in applied science, technology, standardization, research, codification, and engineering economics and industrial management was persisting with success and vigor. Engineers find encouragement in this program.

In so far as the Society itself is concerned, its secretary, Calvin W. Rice, announced at the annual dinner to newly elected members that the number of those coming into the ranks of the Society during the year had exceeded the number of those who had left it because of death or for other reasons. This, combined with a registration at the meeting slightly in excess of that recorded one year ago, attests to its vigor as an institution and to the value of its activities.



A. A. POTTER, PRESIDENT, 1933
The American Society of Mechanical Engineers

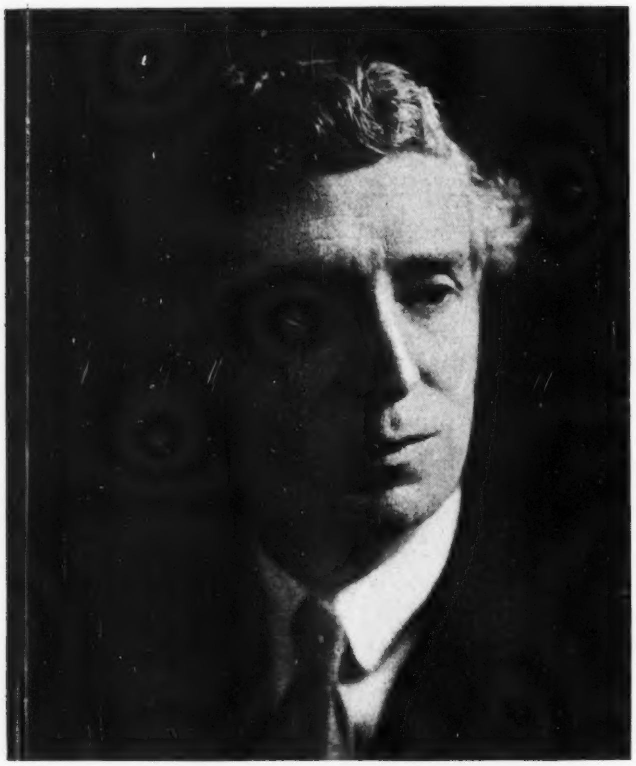
TECHNICAL PROGRAM

No complete description of so extensive and varied an event as the annual meeting of The American Society of Mechanical Engineers can be attempted in so brief a review as the present one must be. Those who are especially interested in the papers and discussions that comprised the technical program will find them in the publications of the Society in due course of time. They group themselves quite naturally into those on the applied sciences so essential to design, the technology of numerous branches of mechanical engineering where operation and practice are the essential factors, and management.

It is a healthful sign that engineers are not neglecting the very sources from which new possibilities of extension and refinement in design may spring, as is abundantly proved by the growing interest in the work of the Applied Mechanics Division. This year's meeting witnessed a symposium on working stresses that was made up of 12 papers and covered three sessions.

In addition to the papers presented by the Applied Mechanics Division, attention is directed to others that fall into the category of science applied to design. There are, for example, those presented by the Special Research Committee on Mechanical Springs, those on the thermal properties of steam, on the flow of fluids, on airfoil theory, and on the mechanism of lubrication.

Of more than usual interest were the papers of the Railroad Division on car design and on materials handling on the railroads. The Machine Shop Practice Division continued its discussion of cutting fluids and the cemented tungsten and tantalum carbide cutting materials, and also provided a session on the foundry. The Iron and Steel Division added to previous papers on heavy-duty bearings and discussed problems of heat transmission, of the rolling and extrusion of aluminum and aluminum alloys, of the use of blast-furnace gas in soaking pits, and of the employment of butane in carburizing. There



W. F. G. SWANN

were also two sessions under the auspices of the Power Division, one by the Fuels Division, one by the Textile Division, one by the Committee on Education and Training for the Industries, and one by the Oil and Gas Power Division, as well as a public hearing, with related papers, on the Test Code for Centrifugal Compressors, Exhausters, and Fans.

Carrying forward the profitable discussions on problems of economics and industrial management that have drawn such large and interested audiences, the Management Division conducted this year a symposium on long-time planning. Two other sessions under the auspices of the Management Division were devoted to industrial management today and to progress in management.

LONG-TIME PLANNING

At the session on long-time planning, ably presided over by Ralph E. Flanders, Sumner H. Slichter, professor of business economics at Harvard University, presented the first paper, entitled "The Problem of Economic Balance." Discussing the questions: "Can industry grow steadily, without frequent collapses which cause us to lose a large part of the ground that we have temporarily gained?" Professor Slichter expressed the opinion that the nature of our economic system precluded the early attainment of this ideal. Industry is kept in operation by the process of buying and selling. This means that industry is peculiarly subject to depressions, because *any* condition which creates a widespread belief that it would be advantageous for buyers to postpone making commitments is bound to result in a substantial drop in production and employment—in other words, in depression.

The conditions which may create a widespread belief that it would be advantageous for buyers to wait are virtually innumerable. This is why it is ridiculous to be dogmatic in designating any particular condition as *the* cause of depressions. The cause which one selects may possess the capacity to produce a breakdown in exchange, but there are many other causes which possess the same capacity and which may precipitate a breakdown before the cause designated becomes powerful enough to act. Any important maladjustment in the economic system may produce a more or less general shock to confidence, and, consequently, a more or less general disposition to postpone commitments.

Probably the most important of all causes for maladjustment between supply and demand is credit. No particular difficulty would be created by the credit system if we did not incur debts part of the time at a faster rate than we could keep up indefinitely. The effect of going into debt too rapidly part of the time is that the community gains purchasing power by going into debt today at the expenses of its purchasing power tomorrow, when it must reduce its indebtedness.

When the causes which may produce a breakdown in the exchange of goods and services are so multitudinous, one would be a blind optimist to expect that we can entirely prevent these breakdowns. Nevertheless much can be done to prevent depressions from coming so frequently, and, once they do come, to prevent them from going from bad to worse. In order that industry may grow without creating such serious maladjustments between supply and demand, there is needed far more complete and accurate market information than we now possess. Particularly important is the closer and more effective control of credit. The rate of expansion must be limited to a rate which can be kept up indefinitely. If we permit credit to expand too rapidly today, we make inevitable a loss of purchasing power tomorrow when the necessary contraction of credit occurs.

To limit the tendency of depressions to go from bad to worse, Professor Slichter suggested the creation of unemployment reserve funds which would be deposited with the Federal Reserve Banks. He also proposed that the construction of public works be concentrated in so far as possible in periods of depression, but warned against the dangers of expanding such activities too early in the depression so that a later contraction of public construction would accentuate the intensity of the depression.

Edgar L. Heermance, industrial economist, of New Haven, Conn., spoke at the same session on "The Trade Association's Part in Coordinate Planning." Mr. Heermance pointed out that Gerard Swope of the General Electric Company had called national attention to the trade association as an agency for the kind of planning that starts at the bottom and works up, rather than that which involves the appointment of a national planning board that must necessarily work downward through the social and economic order to the individual plant. He said that at times he had felt like putting up the sign "Economic planning closed, pending repairs to the credit system," for our most serious problem, overcapacity, was due to the turning of new capital into already overcrowded industries. A great step forward would be taken, he felt, if the Federal Reserve system could set up a control of the volume of available credit in order to keep it in line with the long-term growth in production. However, in his opinion, a good deal was possible at the present time, and even with credit stabilized, the planning of production would be necessary.

Turning to the national trade associations, Mr. Heermance recognized a definite shift in their interests from price protection to industrial planning. This represented an extension of scientific management from the individual firm to the industry. Certain factors like planning for a season and for a series of years, known costs, knowledge of necessary equipment and methods of financing, budgetary control, etc., have been

intelligently studied and utilized in individual plants, but a given company is handicapped by conditions in the industry of which it is a part. The industry, through the trade association, should make a study of its problems, and develop similar plans and controls that have proved so valuable in individual concerns. Studies of markets, reports of conditions within the industry, and industrial budgets, both annual and long-term, would prove most valuable to the industry and to the units of which it is composed.

Broad foundations have already been laid for the application of scientific management to the entire industry, said Mr. Heermance. Many trade associations are already engaged along these lines. Planning, he concluded, was only another name for good business management. The progress of scientific management would, in his opinion extend from the company to industry, from industry to the nation, and from the nation to the international business world. Until planning by industry had made considerable headway, said Mr. Heermance in closing, national planning would have to wait.

These two interesting and valuable papers by Professor Slichter and Mr. Heermance will appear in full in a subsequent issue of MECHANICAL ENGINEERING.

LECTURES AND ADDRESSES

The 1932 Henry Robinson Towne Lecture was delivered by A. W. Robertson, chairman of the board of directors, Westinghouse Electric & Manufacturing Co., New York, on December 6. The lecture was established in memory of Henry Robinson Towne, former president and honorary member of the A.S.M.E., who very early in the Society's history called attention to the essential interest engineers have in engineering economics and whose own principal work lay in this field.

Mr. Robertson, who is chairman of President Hoover's Committee on Industrial Rehabilitation, took for his subject "The Scientific Approach to Human Affairs." Our civilization and our business, he said, were not created for us but were made by ourselves. In this sense, therefore, man controls man's affairs. While many persons had voluntarily accepted the task of remolding and reshaping our civilization, there did not exist at this time, he said, sufficient information on which to base these changes. In so far as machinery was concerned, it was his opinion that the world needed more of it, rather than less, but coordination was necessary so that it would serve, and not harm, man. Continuing, he said:

"The world is puzzled right now by the paradox of overproduction coexistent with poverty, of great riches faced by overwhelming unemployment, of vast material power defenseless against want and fear. We have not adapted ourselves to the new position to which our spectacular scientific success has carried us. We must now discover and devise new principles of economics, new policies of industrial control, new methods of government with which to carry forward the broad front of civilization to the new position reached by the scientific salient that we have so valiently projected into the little-known terrain ahead.

"Before we can find solutions which will help intelligently in the shaping of our lives and human affairs, we must find fundamental facts and laws concerning human affairs which will guide us in arriving at sound conclusions. For this study of our affairs which must be made, to whom may we turn but to engineers and other scientists—men skilled in finding facts and discerning laws—men who are able to distinguish cause from effect—scientists who value their conclusions too highly to make them without due consideration and without proper facts."

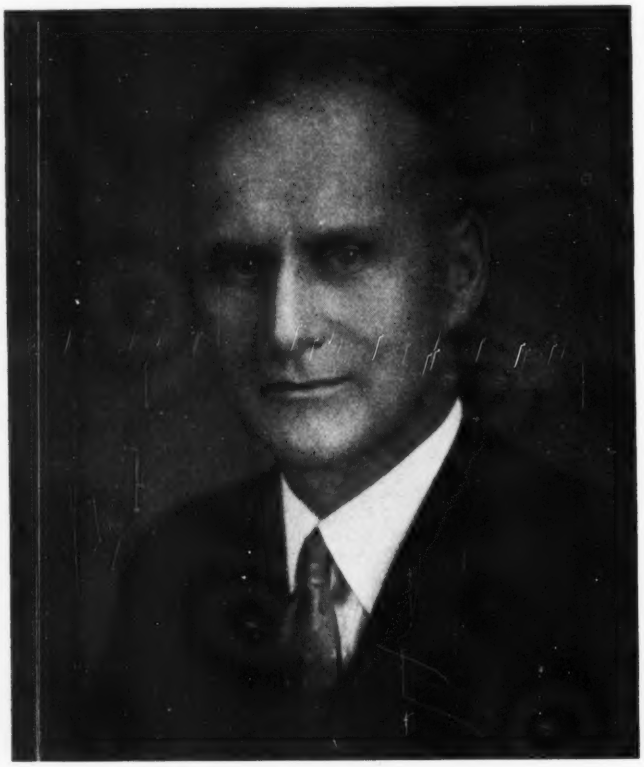
Mr. Robertson then reminded his hearers that we were accustomed to think of the engineer as dealing with the laws of nature, and that if we understood human affairs as well as natural ones we should find them also governed by simple and dependable laws. In his opinion the task of determining these laws was no more hopeless than that which confronted early scientists in solving some of the riddles of nature.

A. W. ROBERTSON

Present conditions, he pointed out, demonstrated the complexity of the operation of human affairs. Our economic machine had run wild and, he added, it was time to develop a governor for it. While innumerable attempts to explain and understand human affairs had been made, they were, generally speaking, a multiplication of words without knowledge. In considering history, he asked, why had civilizations flourished and then decayed? Was it not likely, he continued, that those who lived under them did not know what was necessary to keep them alive or what would cause their death? As sensible persons, therefore, he argued, we should attempt to understand our own civilization so that we might prevent its destruction. It was his hope that we might find reason back of seemingly unreasonable things—a law where now we saw only disorder.

His thesis, therefore, was a call to arms, or rather a call to research to the end that we might learn how to live, as our salvation lay in a study and knowledge of our affairs. In the guidance of these studies he suggested certain basic principles. Coordination, for example, existed quite perfectly in the machine. Our best human organizations fell far below the machine in efficiency. Thus, he asserted, we must learn to coordinate our activities.

At the present time, Mr. Robertson concluded, the Committee on Industrial Rehabilitation, of which he was national chairman, was attempting to stimulate the purchase and installation of equipment and materials necessary to improve or repair its properties. This was a type of coordination and



H. W. HEINRICH

was based on the assumption that the future was uncertain. The Committee, therefore, was attempting to carry the message that financial panic had passed, recovery had begun, and that it could be speeded if we were to take advantage of present prices to spend money for necessary things.

It was Mr. Robertson's parting suggestion that we should study human affairs scientifically in the good years to come in the hope that we might some day control our destinies. Engineers and scientists had solved many problems, he said, and they, or some other wise men, would solve this one.

Dr. W. F. G. Swann, Director of the Bartol Research Foundation of the Franklin Institute, Swarthmore, Pa., delivered the Robert Henry Thurston lecture on "Recent Advances in Physics." This lecture was established in honor of Dr. Robert Henry Thurston, first president of the A.S.M.E. in order to bring to the attention of engineers developments in the field common to engineering and science in which Dr. Thurston was so notable a pioneer.

Dr. Swann pointed out the uncertainties involved in predicting which discoveries would and which would not have a profound effect upon engineering and upon the every-day life of the future. He showed that many phenomena, such as the photoelectric effect, the existence of X-rays, of radioactivity, etc., had played a useful part in pure and applied science without the invocation of much more knowledge of these phenomena than the fact of their existence, coupled with a knowledge of such empirical facts regarding their behavior as could be obtained directly by laboratory experiments. As the usefulness of such phenomena developed, however, the calls upon them in matters of refinement of measurement, constancy of performance, and sensitivity of action became more stringent. The solution of the problems concerned involved a more intimate understanding of the fundamental processes, in atomic behavior, which were ultimately responsible for the phenomena. It is for this reason, he said, that theories even of the most abstract kinds in physics have, in the last ten years, played a greater part than ever before in the crystallization of the actual procedures which should be adopted to obtain ends desired.

Dr. Swann then reviewed the development of our ideas on atomic structure, and particularly of those which have evolved as the result of such work as that of Davisson and Germer on the reflection of electrons from crystals. He discussed the increase of our knowledge of the energies of atomic processes as drawn from study of radioactivity, of phenomena concerned with the disintegration of atoms, of stellar phenomena, of cosmic rays, and of accurate measurements of the weights of the isotopes of the elements.

It is planned to present a more adequate abstract of Dr. Swann's brilliant address in a future issue of MECHANICAL ENGINEERING.

On Wednesday afternoon, H. W. Heinrich, assistant superintendent of the Travelers Insurance Company, Hartford, Conn., delivered an address entitled, "Conservation an Essential in Industrial Recovery."

Mr. Heinrich said that no more profitable time ever existed for a consideration by industrial managers of the prevention of avoidable accident injury. Research indicates, he said, that 98 per cent of all industrial accidents are of a preventable type, and that accidents invariably occur only when there exists a physical or mechanical hazard, or through the unsafe act of some person. He then proceeded to discuss the economic value of accident prevention, and to suggest practicable action that management might take in regard to it.

It was estimated, he asserted, that the annual expenditure for compensation and for hospital and medical treatment because of industrial injuries and deaths, prior to the depression, was $312,000,000. The total cost to employers, labor, and the community was estimated to run into billions of dollars annually. Moreover, he said, the trend, both as to frequency and severity, was unsatisfactory.

Man failure, he said, was largely responsible for accident occurrence, and inasmuch as the direction and control of persons was the special province of management, industrial managers could not escape responsibility until they had initiated appropriate procedure looking toward prevention.

Coming to the subject of what could be done, Mr. Heinrich said that the simplest, least expensive, most effective, and undeniably the most important single step of business management in accident prevention was the decision to record the essential facts of accident occurrence, give them executive attention, and take appropriate action concerning them at regular intervals.

PRESIDENTS' NIGHT

As the leading article in this month's issue is published the presidential address of Conrad N. Lauer, entitled "Unifying the Engineering Profession." This was delivered before the Society on Presidents' Night. Inasmuch as it pertains to engineering-society organization and calls attention particularly to the value of cooperative endeavors by engineering societies, it is of interest to members of any such group.

Following his address, a report of the tellers of election of officers for 1932–33 was read, and the President-Elect, Dean A. A. Potter, of Purdue University, was introduced amid enthusiastic applause. He pledged himself to the carrying on of the traditions of his office as established by his illustrious predecessors, and the earnest sincerity of his voice and manner inspired confidence in his hearers.

Presidents' Night is normally the occasion for the conferring

of awards and honorary memberships. The sudden death this fall of John Ripley Freeman, elected by the Council to honorary membership in the Society, necessitated the conferring of this honor posthumously. Mr. Freeman's classmate and lifelong friend, Charles T. Main, Past-President, A.S.M.E., read a brief résumé of his life and attainments, and the certificate of honorary membership was delivered to Ambrose Swasey, Past-President and Honorary Member, A.S.M.E., who responded in the name of Mr. Freeman's family.

Marshall Anderson, graduate in the class of 1932 of the University of Michigan, was presented to President Lauer for the Charles T. Main Award, for his paper on "Apprenticeship and Vocational Training." It is appropriate to record in this connection that at the Friday meeting of the Council, President Lauer secured the consent of that body to send to President Hoover, Honorary Member of the A.S.M.E., a letter of greeting in which Mr. Lauer expressed the appreciation of the officers and Council of the President's services to the nation and of his demonstration of the effectiveness of procedures initiated after the determination of the facts involved. Mr. Anderson, the recipient of the Charles T. Main Award, handed this letter to President Hoover in an audience granted him on Saturday afternoon, December 10.

Recipients of the other Society awards were unable to be present to receive them. Dr. Alexey J. Stepanoff, design engineer of the Byron Jackson Co., Berkeley, Calif., was awarded the Melville Medal for his paper on "Leakage Loss and Axial Thrust in Centrifugal Pumps." The Junior Award for 1932 was made to Edmond M. Wagner, Jun. A.S.M.E., Kobe, Inc., Huntington Park, Calif., graduate, 1932, of Stanford University, for his paper, "Frictional Resistance of a Cylinder Rotating in a Viscous Fluid Within a Coaxial Cylinder." Student awards for 1932 were made to H. E. Foster, Jr., graduate, 1932, of the University of Tennessee, for his paper "Factors Affecting Spray-Pond Design;" and to William A. Mason, graduate student, 1931–32, at Stanford University, for his paper entitled "An Experimental Investigation of the Flame Propagation in Internal-Combustion Engines."

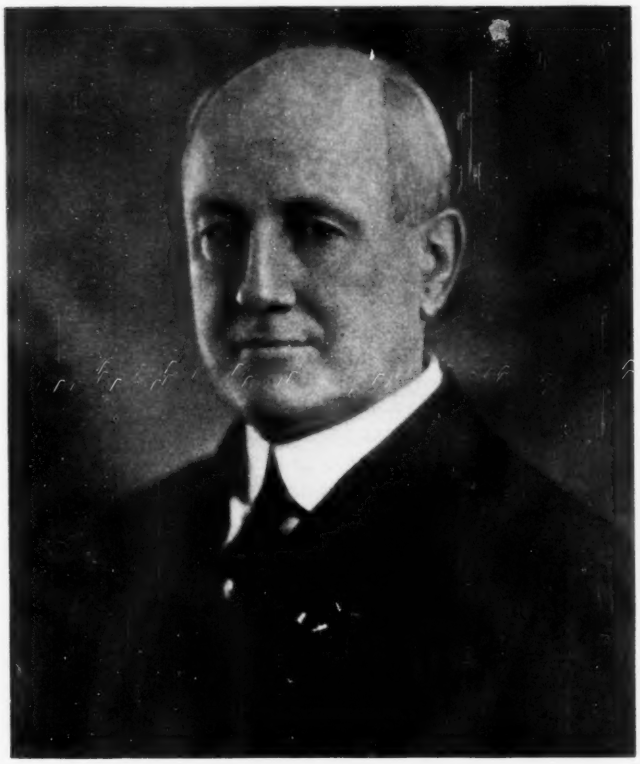
Adjournment was then taken to the fifth floor where President Lauer and President-Elect Potter, with Mrs. Lauer and Mrs. Potter, received members of the Society and their guests. Dancing followed.

THE ANNUAL DINNER

Quite the most enjoyable feature of the meeting was the Annual Dinner, held on Wednesday night at the Hotel Astor. James D. Cunningham, manager of the A.S.M.E., of Chicago, presided as toastmaster with a charm and dignity that was in keeping with the traditional high quality of this occasion. The dinner is made the opportunity to bring the new members of the Society into closer touch with the older ones, and to confer on those who have been members for fifty years badges testifying to that fact.

As Secretary Rice called the names of the new members who were present at the dinner, they rose in their places and were greeted with applause. A stirring address by Past-President Roy V. Wright on the privileges and obligations of membership pointed out that the most was returned to the Society member who put the most into his service to the profession and the Society. Mr. Wright cited John Ripley Freeman and Ambrose Swasey as examples of men who had given much, and who had testified to the great returns along many lines that had come to them.

President-Elect Potter was greeted with loud applause, the audience arising as he was presented to them. He reaffirmed his pledge made the previous night to do all in his power to carry on the work of the Society, and asked for the help and consideration of all members of the Society in his grave task.



J. G. HARBORD

Frederick A. Halsey was the only one present to receive the special badge awarded to fifty-year members, the others being unable to attend.

President Lauer spoke with earnestness and feeling about his year's administration of the Society's affairs, and thanked those who had assisted him and given him their support.

As the final speaker, General James G. Harbord, chairman of the board of directors, Radio Corporation of America, New York, delivered an address on industrial rehabilitation. This address will be found elsewhere in this issue. Dancing followed the dinner.

OTHER FEATURES

While the general reader will find his greatest interest in the public sessions of the A.S.M.E. Annual Meeting as outlined in this brief review, it must be remembered that many technical and other committees make use of the fact that their members are called together in New York at this time of the year to hold committee meetings for the purpose of listening to reports and laying out programs for further work. Delegates from the Society's local sections hold a series of gatherings, starting on Sunday, for the discussion of their problems and for the purpose of informing themselves of the activities, policies, and progress of the Society. The Council also is in session, so that much that affects the welfare and development of the Society takes place during this intensive week. Student delegates to the meeting come together for a session of their own. Numerous luncheons and dinners, excursions, college reunions, and other social and professional events of interest to particular groups add variety to the activities of the week. The more important events have been reported in the December 22 issue of the *A.S.M.E. News*.

MECHANICAL ENGINEERING

Vol. 55 JANUARY, 1933 No. 1

GEORGE A. STETSON, *Editor*

Papers on Public Works

IT IS TO BE REGRETTED that plans for the January issue of MECHANICAL ENGINEERING and the demands and distractions of the annual meeting of The American Society of Mechanical Engineers have made it impracticable to include in this issue a communication from David Cushman Coyle in connection with the article by E. C. Harwood in the December issue. Readers who have followed the discussions on public works and recovery that have been appearing in MECHANICAL ENGINEERING are undoubtedly eager to read Mr. Coyle's answer to Professor Harwood's December article. While Mr. Coyle has prepared his answer, it was impossible to include it in this issue. It will appear in February.

Plan Now for the Future

ONE of the engaging and harmless pastimes of less sophisticated generations was the making, at this time of the year, of resolutions, usually forgotten in the cold realities of midwinter. Perhaps we should return to it. To be sure, spring provides a much more hospitable atmosphere for the emergence of good intentions as it is the season of reviving life and hope. Only a person of unalterable faith can give birth to resolutions of sufficiently rugged constitution to withstand the rigors of the alternate freezings and thawings that advancing winter provides. Life to men of Western civilization is at a low ebb in January, and the pulse of hope throbs weakly until the recurrent miracle of spring is enacted in the world out of doors. No shifting of the calendar or rationalizing on the inevitability of seasonal ebb and flow can quite separate us from instinctive reactions to our external environment that lie deep in our natures. From the dawn of time an instinct has persisted in man and other creatures to hang on until spring. Perhaps it is that instinct, rather than some arbitrarily fixed beginning of a new year, that stiffens men's resolves to give expression to their good intentions and to plan for the future.

Winter is upon us. Cold and profitless and fatal as it may be to some, it is for the world at large the harbinger of spring. It is the season in which those who live to sow and reap prepare the seed, put their tools in order, and plan for the future. Belief in the applicability of this traditional practice to the present economic situation may help to sustain hope and provide occupation for individuals who feel powerless to bring spring to pass by wishing for it. It may or may not be Mr. Robertson's committee or some other endeavor that will provide this occupation. In any event, now is the time for planning, by individuals, by companies, by organizations, and for a bolstering up of faith and resolutions, in order to avoid a conquest by fear.

Rehabilitation

AMONG many plans for improving business conditions is the very practical one of making expenditures for rehabilitation with a view to immediate savings in operating and other costs and in preparation for better days to come. A period of hesitancy can be overcome by starting to do something. As toastmaster at the A.S.M.E. Annual Dinner in presenting General Harbord who delivered an address on this subject, James D. Cunningham, himself engaged in stimulating such activity in the Chicago district, told of many instances in his own experiences in which the actions advocated by the Robertson committee were effective. General Harbord, as will be seen from his address, to be found in this issue, stated the case for rehabilitation at the present moment in convincing terms. Previously, as the Towne Lecturer before the A.S.M.E., Mr. Robertson had put members of the Society into a receptive mood for General Harbord's message.

General Harbord and Mr. Robertson together have supplied the reasons that should bring industry in general to make purchases of machinery, and thereby come to the aid of its manufacturers whose plight in this depression is described by W. H. Rastall in an article also in this issue. If recovery awaits the resumption of buying of capital goods, the machinery industry stands ready to supply replacements for obsolete equipment that should be profitable not only in cutting costs and improving product at present rates of production, but in realizing handsome returns when a greater volume of business is restored.

Economic Aspects of Professional Papers

ENGINEERS must be dollar-conscious—their work demands it. For in the end, almost everything they do is going to be measured by a financial as well as a professional yardstick. Engineers become thus doubly practical and doubly materialistic, for they must serve the dictates of both physical and economic laws.

This economic or financial aspect of engineering problems adds interest as well as hazard to the work of engineers. It should therefore be given proper consideration and authors should not feel that it is out of place in papers and addresses in which they describe their work to fellow-engineers and laymen. No plea is made here for a commercialism expressed in terms that advertise a private interest before a professional body. Professional-society papers must not be lowered to such standards. But in-

terest, as well as value, is added to a paper in which some attention is paid to the economic considerations and advantages that may be an important factor in the subject discussed. The dollars of saving involved speak with a louder voice and to a broader audience than does a fractional increase in theoretical efficiency. The economic consequences of a new or improved design are more potent factors in securing its adoption than the novelty and ingenuity of the mathematical analysis or experimental investigation upon which the design is based. As practical men, engineers should recognize the interest that others have in these important and practical aspects of their work.

Education as a Continuing Process

THOSE who criticize engineering education as being narrow and devoted to the making of a living rather than to the art of living more abundantly, fail to remember the origins of some of our most distinguished universities and to realize that engineering education may accomplish both of these objectives. As Dr. Baker points out in an article in this issue, a training for the ecclesiastical service was the foundation of many modern universities. Later a broadening of the functions of these institutions of learning added an aura of intellectual and social respectability to practitioners in the legal, medical, and other professions, including those of engineering and business administration. As education is conceived of today there are fewer attempts to insist that an educated man must spend four years with a group of studies intended primarily to serve as an intellectual background for churchmen, but liberalized by contacts with the history and literature of ancient and medieval civilizations; and there is greater recognition of the value of understanding the culture of our own times, and of preparing intelligently for its immediate development.

Education so conceived of relies upon such an abundant and varied subject-matter that specialization in inevitable. It is, however, far from being narrow; and its integration into contemporary progress can be accomplished by careful direction. Engineering schools and their post-collegiate counterpart, the engineering professional society, have grave responsibilities in this connection. The latter picks up where the former leaves off. Without invading each other's field they can cooperate to lessen the severity of the interruption that is bound to occur in the educational process when engineering graduates enter the ranks of apprentices in the engineering profession.

A major purpose of MECHANICAL ENGINEERING is to assist in that critical phase. Somewhat more than a year ago curves showing the 1930 earnings of mechanical engineers, arranged according to ages, were published. They showed that the period of professional development up to approximately forty years of age was that in which ability, opportunity, and training were consolidated into conditions that apparently determined the degree of achievement in later life. Divergence of individuals from the main groups was most noticeable after this age had been attained. The most useful service that MECHANICAL ENGINEERING can perform is to provide stimulating reading matter for engineers and to urge especially on men still in this early stage of their careers the importance of giving thoughtful consideration to the variety of subjects discussed in its pages.

The E.C.P.D

ANNOUNCEMENT was made sometime ago of the organization of the Engineers' Council for Professional Development in which the American Society of Civil Engineers, the American Institute of Mining and Metallurgical Engineers, the American Institute of Electrical Engineers, the American Institute of Chemical Engineers, the Society for the Promotion of Engineering Education, and the National Council of State Boards of Engineering Examiners joined with The American Society of Mechanical Engineers to set up a new agency for the coordination and promotion of efforts directed toward higher standards in the engineering profession. In the September issue of MECHANICAL ENGINEERING, C. F. Hirshfeld discussed the purposes of the new Council, and those who wish to refresh their memories with regard thereto are directed to his illuminating exposition of them.

Since Mr. Hirshfeld prepared this statement of what the new Council proposes to accomplish, its organization has been completed. Three members on the Council have been appointed by each of the seven participating groups, and four committees have been set up within the Council, dividing the responsibility for its immediate program among them. These committees and their chairmen are: (1) Selection and Guidance, Harrison P. Eddy, (2) Engineering Schools, Karl T. Compton, (3) Professional Training, Robert I. Rees, and (4) Professional Recognition, Conrad N. Lauer.

Engineers will watch with keen interest the progress of the Engineers' Council for Professional Development. The Council is auspiciously inaugurated at a time when the seriousness of contemporary events leads to thoughtful consideration of any plan that has promise of a broad usefulness. This the plan of the E.C.P.D. has, as will appear if the full possibilities of the studies undertaken by the four committees already set up are realized. Such realization depends upon the vision and wisdom of the individuals of whom these committes are composed. It is not to be expected that a few months of study will produce in final and perfect form the hoped-for results. And as details of a program of action for the engineering profession are made public, the engineering profession itself must supply the enthusiasm and driving force to see that they are properly considered and developed. It behooves individuals to become acquainted with what the E.C.P.D. is trying to accomplish and support its endeavors. In the last analysis the success of the Council's work will be measured by the degree to which their recommendations are carried out by the entire engineering profession.

INDIVIDUALISM AMUCK[1]

IT IS GRATIFYING to find in September MECHANICAL ENGINEERING two more papers on the economic depression, which gives hope that we may soon agree in advocating some measure or policy to alleviate these scourges. Dr. Gregory, an English authority on economics, recently stated that it seems necessary to cure this evil in order to preserve existing economic processes. Sober judgment, however, mollifies this thought when we reflect that like booms and depressions, some far more acute than the present, have occurred now and then through a period of time whose beginning antedates the Christian era.

DEPRESSIONS FUNDAMENTALLY ALIKE

A survey of these depressions discloses the fact that their fundamental causes and character are alike, and that these causes bear no direct relation to engineering. Consequently any measures that we may now put forward we must advocate as citizens and not as engineers; that is, we now have that long-waited-for opportunity to take action in public affairs. In order to arrange a synopsis of the process of depressions, let us refer to Mr. Flanders' article.[2] There are, of course, innumerable factors producing their effects on a depression, some of which as set out under ten headings in the article mentioned are purely engineering and modern, and hence did not contribute to the medieval and ancient cataclysms. The factor that we find common to all these collapses and generating them is their financial character. Who can find any machine or efficiency effects in the South Sea enterprise or in the simultaneous Mississippi adventure? What we find there is widespread public participation in exaggerated expansion, with some shifty work involved, no doubt.

If a business community existed without increase of debt, public or private, commerce would be simple and complete, and one might reason as in section (5) of the article cited. It is instructive to consider for a moment such a society. This is a pay-as-you go condition for all, and no depressions as we know them could supervene, although suffering might come from natural disasters and even from misdirection of economic endeavor such as in the manufacture of useless products. With no increase of debt or credit there could be no accumulation of savings except of material goods or money hoarded. It follows, for example, that life insurance could not be conducted as it requires investment. Money hoarded would tie up an equivalent amount of trade unless circulation correspondingly increased as Mr. Flanders states. When we pay for our purchases we generally are more circumspect and careful than when getting things on credit, and especially does this apply to public endeavor; so that a pay-as-you-go society should be more efficient than one which "lets George (posterity) do it."

In our credit society Mr. A builds a house, paying for it with funds secured on a mortgage. This transaction is in effect a loan by society of the labor and materials represented by the mortgage, for which it will be repaid in the future. The result is that Mr. A has a house that did not previously exist, and he has set up a debt or credit, while society has made a saving of like amount. Credits and savings balance. The capacity of society for production of this character is limited only by its faith in its debtors and the willingness of the latter to work and store up savings. In a real-estate or security transaction in an appreciating market one may sell for, say, $5000 that for which he paid $3000 and accept from the purchaser $3000 in cash and a $2000 credit obligation. Then by the sale a debt and balancing saving of $2000 is set up—one might say generated, as are the opposing charges of electricity in an induction machine. No bank need be involved. For trade and commerce the required credits are set up by the merchant applying to his bank for short-term loans. This credit currency, so called, takes the place of specie currency; it is elastic; it is buying power; it exists in far greater volume than specie currency. There is no point in hoarding savings in this financial system since the credit volume overwhelms any normal hoarding and, as stated previously, replaces it as expanded currency.

Now we are prepared to understand depressions. All of them have been involved in credit and the destruction of credit. One in Caesar's time was apparently generated by a succession of natural calamities, but nearly all have had the same characteristics of expanded credits, reaching stages where the denizens became scared of their shadows, and where truly to hesitate was fatal. This is because the debtors' ability to repay is apparent enough during expansion, but as this slows up the situation is universally seen to be impossible. During the past three years banking loans and discounts have been reduced by fifteen billions—fifteen billions of buying power was wiped out.

But banks and credit institutions should not be charged with responsibility for credit extensions and collapses. They are the handmaidens of business leaders, and would be roundly berated if they withheld credits from any promoter because such credits were socially inopportune. Let us advocate the establishment of a tribunal as suggested by Mr. Seibert, if not with power over credit systems, then charged with frowning publicly on credit abuse.

REAL PROBLEM THE CREATION OF CREDITS AND DIRECTING THEM INTO PRODUCTION OF WEALTH

In conclusion, let us consider our present predicament. We have had a collapse and business is stagnant, unemployment rife, and prices next to nothing because of sellers' necessities to meet commitments. How shall we effect a resurrection? Credit is the answer; credit is the motive force of our business system. Start the induction machine! So we find the Reconstruction Finance Corporation creating one and a half billions of buying power and, what is more important, a great increase in the market prices of depreciated bonds. Men and institutions owning bonds at thirty cents on the dollar have no buying power; they have trouble. It is said that the appreciation is in anticipation of business recovery. We need not quarrel with that idea, but perhaps instead it is the making of business recovery.

However, the real problem remains unsolved—that of directing these credits into production of wealth. If they are squandered in a way that will leave us only with the obligation to repay them from the means now at hand, we shall not have lifted ourselves out of the depression but plunged further into it. Therefore the wealth secured with these credits must be real; that is, it must be capable at least of self-liquidation—it must increase our ability to repay correspondingly. Here is where engineers may be of service if agreed on the policy, but we find them divided on this necessity for self-liquidation.

[1] Contributed by E. S. Martin, Mem. A.S.M.E., Secretary-Treasurer, James A. Wickett, Ltd., Toronto, Ont.

[2] "The Economics of Machine Production," by Ralph E. Flanders, MECHANICAL ENGINEERING, September, 1932, p. 605.

SURVEY OF ENGINEERING PROGRESS

A Review of Attainment in Mechanical Engineering and Related Fields

AIR ENGINEERING

A New Free-Piston Engine Compressor

THERE is now coming into use in Europe a new type of free-piston oil-engine air compressor without connecting rods, cranks, valves, spark plugs, or flywheel. Its moving parts are in perfect balance. The inventor is the Marquis de Pescara, with headquarters in Paris.

Referring to the cross-sectional drawing, Fig. 1, the operation of the compressor is as follows: The two opposed free pistons slide in and out in synchronism, insured by a lever

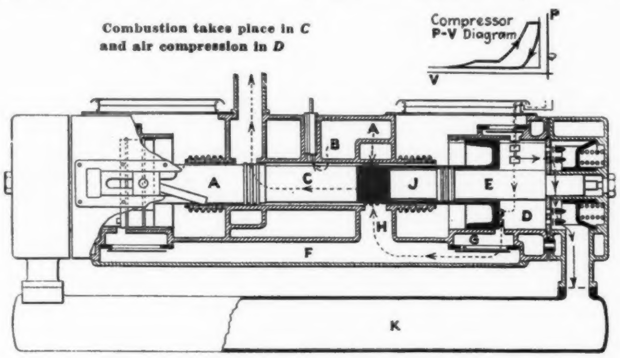


FIG. 1 FREE-PISTON ENGINE COMPRESSOR

pivoted at its center and connected by side rods to the two pistons. These rods do not normally transmit any power; their work is merely to absorb the slight incidental variations in the operation of the pistons and keep them in step. The oil pump, however, is operated by this mechanism.

In effect, the pistons are entirely free of mechanical connections and act as engine pistons on the inner ends and as compressors on the outer ends. All power is produced in space *C*, according to the Diesel two-stroke cycle. Fuel oil is injected at *B* in proportion to load.

A coil spring (not shown) is cranked up for starting. The two pistons are driven together by the action of this spring. At the proper point explosion takes place and forces them out. This outward movement compresses air in the annular space *D*.

During the first stages of compression, part of the air is bypassed through the plate valve *G* and acts as scavenging air, passing through *H* into the combustion space *C* and out through the exhaust. As the stroke continues, the bypass port is closed and the air pressure builds up for delivery to the receiver *K*, from which it passes to the outside application.

Compressed air locked in space *J* by the secondary fixed piston *E* acts as a cushion to insure return of the piston *A*, regardless of the load on the compressor ends. All of these actions, of course, take place simultaneously at both ends of the machine, which is symmetrical in all respects except for the location of the scavenging and exhaust ports.

The author has operated three of these machines at the factory and believes them to be the simplest of prime movers. (J. Gould Coutant, Fuel Engineer, in *Power*, vol. 76, no. 5, Nov., 1932, p. 237, 1 fig., *d*)

APPLIED MECHANICS

The Work of Rivets in Riveted Joints

THE subject of this paper is an investigation of how a force acting on a joint made up of plates divides itself among the rivets. A qualitative study of the subject is followed by the derivation of formulas for the forces developed by the rivets in a few simple types of joints, based on the assumption that a rivet develops a force proportional to deformation.

These formulas are then applied to the determination of the numerical values of the forces acting on the rivets based on the value of the coefficients found analytically. In his introduction the author points out that, despite their widespread use in engineering, riveted joints and the actual work on such joints when stressed are not well understood.

One difficulty is that inelastic deformations begin to take place a considerable time before the limit of safety is reached. Furthermore, formulas that could be developed along more or less rational lines would be difficult to use in actual practice, except in plate work (boilers, tanks, etc.). Nevertheless, the author attempts to present an analysis which, while admittedly not perfect, may raise some questions of interest for discussion.

"Standard practice" has developed several arbitrary methods of design that remain in vogue mostly because they are convenient. Consider the simple case of a lap joint with two plates in tension, connected by several rows of rivets equally spaced. Imagine the joint to be divided longitudinally into equal strips with one row of rivets in each, and consider one strip as representative of the work done by the entire joint.

The author shows that a method of design based on allowing a uniform value for each rivet working in friction is wrong, but if the friction force and the coefficient of proportionality between the shearing force developed by a rivet and its deformation are determined by experiment, a reasonably rigid theory of a riveted joint may be deduced by means of a mathematical analysis, which the author proceeds to do. He accepts it as evident that the value of the friction force may vary widely for the same size of rivet, depending on how well the rivet has been driven, and for a bad rivet it may approach zero. In that case the rivet works only in shear and crushing, and develops a force proportional to deformation. Formulas developed under this assumption will be on the safe side.

On the other hand, the author points out that a rivet cannot work in shear and bearing without deforming, and that a perfect rivet does not deform until the friction force between the plates caused by tension in the shanks is exceeded.

The author gives numerical values of the forces of the rivets. He introduces what he calls a distribution coefficient, *C*, which is the fraction of the total force taken by each rivet according to conventional design (reciprocal of the total number of shears in the joint). The equations presented in the paper with the values given in the table of distribution coefficients lead to the following conclusions:

The standard practice of dividing the force in proportion to the shearing areas of the rivets and disregarding the deforma-

tion of the plates leads to results that are very inaccurate. In a 6-rivet lap joint the overstress of an outer rivet designed by the conventional method may be more than 100 per cent, and in a joint with a greater number of rivets, the overstress seems to be still greater.

Actually, the total force acting on a riveted joint is not distributed equally among the rivets; a larger proportion of the total work is done by the outer rivets.

The proportion of total work in the outer rivets increases as the pitch and diameter of the rivets increase and the cross-section of the plates decreases.

If there are many rivets in a longitudinal row the inner rivets are inefficient, and an increase in the number does not improve the value of the joint appreciably. For example, in the table of distribution coefficients (Table 1 in the original article), comparing the values for 5-rivet and 6-rivet joints, it is seen that when the number of rivets is increased from five to six (that is, by 20 per cent) the force on the outer rivet decreases only by 2.3, 0.6, 6.6, and 3.3 per cent, in the four cases given.

It seems likely that in joints containing twenty or more rows of rivets, some of those in the middle perform no work and those on the outside are overstressed greatly. However, no engineering structure has ever failed because of this lack of uniform distribution, due to the ductile nature of structural steel. After the outer rivets have been stressed beyond the elastic limit, they do not break, but deform almost without increase in stress, and this brings the inner rivets into play. If the rivets were made of some brittle material, the inaccuracy of the conventional-design method would soon manifest itself in the failure of the rivets.

Another factor that helps the outer rivets is friction between the plates, which has been disregarded entirely in this analysis. Actually the rivets do part of their work by friction, which involves no deformation and retards the moment when the stress in a rivet exceeds the elastic limit.

The method of distributing a force through the rivets of a joint as presented in the paper might prove of practical value in the design of boilers, tanks, and similar structures. The necessary coefficients could be computed quite easily for standard values of pitch, width of plate, thickness of plate, diameter of rivet, and for type of joint. Such data could then be plotted into curves for the use of designers. As stated in a previous paragraph, the rivet coefficient k would be determined by experiment.

Of course, the greatest disadvantage of the method is that it is less economical than the present standard method of equal distribution. Furthermore, the author does not recommend it for general structural design of buildings, bridges, etc. However, he ventures to offer for discussion a few suggestions concerning the standard design of connections of structural members, in the hope of promoting conditions that will insure more uniform distribution of forces among the rivets, namely:

1 In compression members, the number of gage lines should be increased. This would reduce the number of rivets on each gage line, and hence the inequality of forces taken up by the rivets. Naturally, it would be more difficult to apply this recommendation to the tension members, due to the consideration of the net section.

2 A minimum allowable longitudinal pitch should be established, since the inequality decreases with the decrease of pitch. Although this is being generally done in common structural practice, sometimes the pitch is lengthened due to a desire to eliminate an extra cut on the gusset plate. (A. Hrennikoff in *Proceedings of the American Society of Civil Engineers*, vol. 58, no. 9, Nov., 1932, pp. 1507–1519, 5 figs., *tm*)

ENGINEERING MATERIALS

Heat Developed by Cement While Setting and Hardening

THE author lists the factors influencing the degree of temperature rise in concrete and tells how the heat of hydration and other factors, including the specific heat of dried powdered concrete grouts, were measured.

The following summarizes the main features of the article. The total heat-generating capacity of cement during hydration is independent of its surface area or particle size, and is little affected by prehydration within practical limits.

Particle size and prehydration affect the rate of heat liberation and therefore its time-temperature relation, many other factors also affecting this relation in concrete. Low tensile and compressive strength up to 28 days in specimens made from coarse-ground or prehydrated cements cured at ordinary temperatures is due to a slow rate of hydration, but this is no indication of their performance in mass concrete.

Low temperature rises with coarse and prehydrated cements used in neat grouts are due to a lesser degree of hydration. In mass concrete where it is reasonable to expect the end products of hydration to be about the same, similar quantities of heat will be developed per unit of cement used, although the time-temperature relation of the heat developed may vary.

The total amount of hygral heat of cement can be altered more readily by changing its chemical composition. (S. L. Meyers, Chief Chemist, Southwestern Portland Cement Co., El Paso, Tex., in *Rock Products*, vol. 35, no. 19, Sept. 24, 1932, pp. 22–26, including brief list of references, 4 charts, *e*)

Beryllium

THE paper here abstracted deals primarily with the practice of Siemens & Halske, who introduced beryllium oxyfluoride as an electrolyte. This compound is used chiefly in mixture with barium fluoride which is said to permit maintaining continuous operation of the bath without decrease in beryllium concentration. There is no separation of barium, and the best yield is secured when the electrolyte consists of equal parts of barium fluoride and beryllium oxyfluoride. The presence of iron or aluminum in the electrolyte causes these metals to appear in the beryllium, but the cooled iron cathode introduces practically no iron into the product. The volatilized fluorides are recovered and returned to the bath. Alloys of beryllium and aluminum did not produce anything attractive, while it has proved impossible to produce beryllium-magnesium alloys. As a matter of fact, alloying copper with beryllium promises to be quite important.

Beryllium bronzes are already used for springs as they possess a peculiar mechanical and chemical resistance, and show very slight fatigue phenomena. Leaf springs have endured 10,000,000 bends and remained undamaged. Phosphor-bronze leaf springs, on the other hand, when submitted to the same test, failed after about 400,000 bends—the very best at not more than 1,000,000 bends. For example, in the case of electric locomotives, the continuous jarring causes brush holders and contact caps to last but a few weeks when made of a bronze not containing beryllium. The resulting necessary renewals are very disturbing and add to the uncertainty in railway operation. The use of beryllium bronzes eliminates this uncertainty. These Be-bronzes will also find application in the construction of aircraft and ships, as, for example, in the suspension springs of airplane landing gears where special strength is needed to withstand the heavy shocks that often occur during landing. The bronzes are

specially suited for those parts of electric motors and internal-combustion engines that have to withstand heavy impact. The high resistance of the bronzes to corrosion and to erosion renders them suitable for pumps, liquid meters, turbine blades, and the like. They may be substituted with advantage wherever aluminum phosphor-bronzes have hitherto been employed and developed noticeable weakness. In contrast with castings of aluminum bronze, those of beryllium bronze show complete freedom from oxides, a greater density, and a greater strength at higher temperatures, which is often an important property. In many cases beryllium bronzes will undoubtedly be employed because of their greater reliability, even though the initial cost is higher. Alloys of beryllium with nickel or cobalt, as well as the three-metal systems beryllium–copper–zinc and beryllium–copper–aluminum, possess similar useful properties.

The work on beryllium-iron alloys is proceeding. The installation now operated by Siemens & Halske can produce a few tons of beryllium annually. According to its degree of purity, beryllium costs from 18 to 65 cents per gram ($80 to $300 per lb). The price of the beryllium alloys corresponds generally to their beryllium content. As the consumption of beryllium becomes more extensive and its production increases, one may expect a considerable reduction in its price. Certain alloys such as the beryllium bronzes may be produced relatively cheaply by direct methods, without the necessity of first preparing pure beryllium. (Alfred Stock, Professor, Technical High School, Karlsruhe, Germany, in *Transactions of the Electrochemical Society*, vol. 61, 1932, pp. 255–272 and discussion, pp. 272–274, *dp*)

Determination of the Porosity of Tin Coatings on Steel

THIS investigation was carried out for the British Non-Ferrous Metals Research Association as a part of the work in progress aimed at improving the quality of tin plate, with the support provided by the members of the Association in the British tin-producing industry.

It has been found by the authors that when tin-coated steel is kept for some time in hot water of high purity, spots of iron rust appear over its surface; these spots are sharply localized and strongly adherent.

To secure the maximum number of spots, the following conditions are essential:

a The water must be of high purity. Small additions of any one of wide variety of salts inhibit the test. Water prepared by distillation and stored under conditions free from contamination is satisfactory.

b The hydrogen-ion concentration of the water should be within the approximate limits pH 4.5 to 7; thus, the water may be neutral or very slightly acid, but must not be alkaline. As a simple test it has been found that the water is suitable if it gives a pink color with methyl-red indicator.

c The temperature of the water during the test should not be less than about 95 C.

d The time of immersion of the specimen should be about 6 to 8 hr, or 3 hr if it subsequently remains immersed for an additional period of 18 hr in the water at room temperature.

The following evidence indicates that the number of rust spots so obtained is a satisfactory index of the porosity of the coating:

1 During the test an exceedingly thin film forms on the surface of the tin coating, giving it a golden-yellow appearance: this effect is confined to the extreme outer surface of the coating and does not affect its continuity.

2 The tin-iron compound $FeSn_2$ is unaffected by the test. The rust spots can therefore only appear at actual breaks in the coating; on the other hand, visible amounts of rust may be produced at exceedingly fine pores since:

3 The conditions of the test strongly favor the anodic attack of exposed steel and the formation of rust in such a way that progressive attack of the steel from which it is derived is not obstructed.

The results of ferricyanide tests have been compared with those obtained by the hot-water test.

Details of the ferricyanide test are given in the original article, where also the efficiency of the ferricyanide-jelly and ferricyanide-paper tests are compared.

For testing tin plate which has been cold worked, as by stretching, bending, buffing, etc., the ferricyanide-paper test proved unsatisfactory owing to the attack of the tin coating by the reagent, which took place at the areas of the sheet which had been deformed by cold work.

The hot-water test, however, has proved satisfactory, and the results of a number of tests are given.

It should be added that preliminary tests have shown that pores in other cathodic coatings on steel—such as nickel, chromium, and copper—are also revealed on immersion of the coated metal in hot distilled water, the development of the rust spots taking place more rapidly than in the case of tin coatings on steel. (D. J. Macnaughtan, S. G. Clarke, and J. C. Prytherch in a communication from the Research Department, Woolwich; abstracted through *Sheet Metal Industries*, vol. 6, no. 2, June, 1932, pp. 75–81, illustrated, *p*)

FOUNDRY

Pulverized-Coal Rotary Furnaces for Melting Iron

THE foundry in which these furnaces were installed belongs to Sir W. G. Armstrong, Whitworth & Co. and forms part of the Close Works at Gateshead-upon-Tyne, near Newcastle, and is intended for the manufacture of castings for the automobile trade, Diesel engines, hydraulic machinery, etc. A substantial amount of this work calls for high-duty cast iron. Previous to selecting the proper type of furnace the company investigated claims for rotary furnaces fired with pulverized fuel. These furnaces had already been in operation for some time in certain Continental foundries, and were mainly of two types, the German Brackelsberg furnace and the French Sesci furnace, while in Great Britain the Sklenar rocking furnace was being developed.

To start with, a five-ton Sesci furnace was installed. After a period of tests and following various modifications made principally to the coal-pulverizing plant and to the control system, three more furnaces were installed.

The Sesci furnace was described in the November 15, 1930, issue of *The Foundry*. However, certain modifications have been made by the engineers of Armstrong-Whitworth, the principal one being the substitution for the charging methods used in the French plant of a Wellman-Smith-Owen 3360-lb ground-type charging machine, similar to that used in the open-hearth steel plant.

The charging machine runs on a platform parallel to the line of furnaces. A movable head mounted on wheels is in front of the charging end of each furnace. This collects the gases from the furnace and conducts them to the recuperator, where air is preheated to 500 C before entering the furnace. At the time of charging, a ram of the charging machine pushes the movable head on one side, thus rendering the charging end of the furnace free. When the charging operation is complete, the charging machine pushes back the gas collector

in front of the extremity of the furnace. Charging boxes are loaded in the stock yard, and are placed on the tables between the platform and the line of furnaces by an overhead crane. The battery of furnaces is placed at one extremity of the foundry bay, the width of the plant being in the neighborhood of 40 ft.

Pulverized bituminous coal is used for starting up, but after the ingoing air reaches a temperature of 200 C (392 F), anthracite is turned on and the bituminous coal shut off. Pulverizing is accomplished by forged steel balls which are pushed around the manganese steel track at about 260 rpm. The finished product must be of a fineness equal to 85 per cent through a 200-mesh sieve.

An interesting detail is the system of control for the rotation of the furnaces, which has been designed by the engineers of Armstrong-Whitworth, and is by motor, gear box, and chain drive. Control is effected by push buttons with electrical gear. Simply by pushing two of a set of buttons, one can start the furnace rotating in one direction or the other, and the speed of rotation is determined by the gear box, a slow motion being obtainable for tapping purposes. This control is extremely easy to operate, and one man can take care of the four furnaces.

The total number of men necessary to operate the plant in full is as follows: Two crane drivers, one operator, two tappers, 1 charge operator, four laborers, 1 weighman, and one boy. In addition, one man is required for the coal-pulverizing plant.

The charges used for these furnaces vary, naturally, in accordance with the job, but up to 80 per cent scrap can be used in the charge. The firm also uses these furnaces to manufacture a specially refined pig iron which they market under the name of New Process pig iron and which they are prepared to sell to any exact analysis. The four furnaces described can supply as much as 22 tons of molten iron in one operation.

The outstanding feature attributed to the furnace is the effect of the high temperatures obtainable. The effect of superheating cast iron is to produce in the final, solid material an iron wherein the graphite is in an extremely fine, evenly disseminated condition in a matrix of pearlite and ferrite, depending on the degree and length of time of such superheat.

Discussion of the metallurgical process in the rotary furnace follows in the original article. (Vincent Delport, European Manager, *The Foundry*, in *The Foundry*, vol. 60, no. 11, September, 1932, pp. 26–27, 63–64, 3 figs., *d*)

FUELS AND FIRING

Fuel Economy in Domestic Automatic Heating

THE annual domestic coal bill for the United States is approximately $800,000,000, the larger part of which is for bituminous coal. The average efficiency at which this coal is burned is indefinite, but an optimistic figure would probably not exceed 50 per cent.

The purpose of the present investigation was to determine the efficiency of domestic heating, and particularly to take the data within the home over the normal winter heating cycle, both daily and seasonal, in such a manner that it would represent average rather than special conditions of manipulation, and then compare hand firing and stoker firing, the latter with and without economizer.

A general theory of combustion for hand and stoker firing in a typical hot-water heating plant is presented, and the conclusions arrived at are well worth attention. Thus it is stated that because of improper design of the combustion chamber of the average domestic furnace, the householder, without realizing it, is penalized from $3 to $5 a ton for lump coal over the cost of mine run in order to get fair combustion.

Data are given for typical hot-water heating plants, hand-fired, stoker-fired, and stoker-fired with a hot-air economizer attached.

It would appear that the adoption of stoker firing increased the efficiency approximately 15 per cent. Moreover, in the locality of the tests (State of Washington) hand firing requires a lump coal costing $13.50 per ton delivered, while steam slack which can be used in stoker firing costs $8.50 to $9 per ton delivered, and the automatic heat control of the latter gives a more uniform temperature over the 24 hr.

Such matters as relation between heat-exchange surface and flue-gas temperature, the effect of dirty heat-exchange surfaces, and comparative costs of domestic heat with oil and with coal are discussed. It is claimed that with oil at $8^1/_2$ cents per gal and coal at $8.50 per ton, the extra cost of heating a residence with oil as compared with stoker-fired coal in a typical heating plant amounted to $88^1/_2$ per cent. [Howard H. Langdon and Homer J. Dana in *Monthly Bulletin of the State College of Washington*, Pullman, Wash. (also bearing subtitle of *Engineering Bulletin*, no. 39, Engineering Experiment Station), vol. 14, no. 10, March, 1932, pp. 3–44, 11 figs., *ec*]

Flame-Proof Gasoline

THIS term is applied to a gasoline that is non-inflammable except under conditions prevailing within the cylinder. It is stated that the new fuel here described is so resistant to burning that one may actually hold a lighted match over it without fear of fire.

By "non-inflammable" is meant a material with a high flash point, and the fuel under consideration must be heated to 107 F before it will ignite. One of the difficulties in the production of a fuel with a high flash point lies in its tendency to produce knocking or detonation. It is claimed that the new fuel is substantially free from this tendency. Its production is one of the outcomes of the application of hydrogenation process. The details of the method of manufacture are not stated. (Gustavus J. Esselen in the *Esselen Bulletin*, abstracted from a reprint in the *Journal of the Engineering Societies of Boston*, vol. 3, no. 6, June, 1932, pp. 8–10, *d*)

HYDRAULICS

Experiments With Capillary Jets

THE present investigation is a continuation of the work contained in an earlier paper entitled "The Characteristic Curves of Liquid Jets," in which examination was made of the behavior of different liquids issuing vertically downward from a capillary tube under varying experimental conditions, an extension also of the work of Smith and Moss.

The apparatus for producing the jets differed from that previously used in some respects. An inverted glass bottle supported vertically was connected to a large reservoir provided with an air manometer and a valve through which air could be pumped. With the liquid in the bottle and the nozzle attached at the lower end, the pressure in the reservoir was gradually increased step by step, and at each stage, with the liquid issuing freely downward, the jet length was measured by means of a cathetometer microscope, and the corresponding velocity of efflux determined by collecting the volume of liquid in a known time, and weighing. The pressure during

each set of operations remained constant because of the large reservoir used.

The following summary is reproduced from the original paper: Examination is made of the properties of capillary jets concerning the causes which are of primary importance in controlling the relation between the continuous length of the jet (L) and its velocity of efflux (V) from a cylindrical nozzle.

Characteristic L-V curves exhibit upper and lower critical velocities, at which discontinuity in the jet length occurs, with an L-V streamline part for intermediate speeds.

Whereas viscosity and surface tension of the jet fluid are the prime factors controlling the upper critical point, drop-formation disturbance produced at the disruption point of the jet, gaining access to the nozzle, is the cause of the lower.

Particular cases of liquid jets formed in air more viscous than previously used, reveal modification of both the streamline characteristic and upper critical velocity as a result of increased viscosity.

Liquid jets formed in other non-miscible liquids enabled the controlling influence of the surrounding medium with respect to viscosity and density to be investigated.

Photographs of capillary jets produced under varying conditions are included, together with dimensional formulas covering the various phases examined. (E. Tyler and F. Watkins, College of Technology, Leicester, in *London, Edinburgh and Dublin Philosophical Magazine and Journal of Science*, vol. 14, no. 94, Nov., 1932, pp. 849–881, 17 figs. [these include 4 plates of photographs], *eA*)

INTERNAL-COMBUSTION ENGINEERING (See Fuels and Firing: Flame-Proof Gasoline)

MACHINE DESIGN

Predicting Worm-Gear Efficiency

IN EARLIER articles (*Machine Design*, February and April, 1932), W. H. Himes presented a formula for the efficiency of worm gears. In the present article the author gives a family of curves, plotted from the Himes formula, for the range of possible coefficients of friction for different load angles of worms, while another graph gives the coefficient of friction as it varies with the rubbing speed when using a case-hardened, ground, and highly polished steel worm mating with a bronze wheel and lubricated with mineral oil. By the use of these two graphs the efficiency of any worm gear may be predicted easily, provided that particulars of the worm are known.

It is stated in this connection that, from the work of Dr. Henry E. Merritt, chief of the David Brown Research Organization, the rubbing speed is a function of the load angle and hence is dependent on the design of the worm to some extent. It is obtained from the following formula

$$\text{Rubbing speed} = \frac{0.262\, dn}{\cos \lambda} \text{ ft per min}$$

where d and n are respectively the pitch diameter and speed in revolutions per minute of the worm, and λ is the load angle. In regard to other conditions governing the coefficient of friction, the most important is the type of lubricant. The best combination of materials was found to be a $3^1/_2$ per cent nickel case-hardened steel worm and a straight bronze wheel containing up to 13.5 per cent tin and up to 0.1 per cent phosphorus. By altering the proportions of the tin and phosphorus, a variation in the coefficient was seen quite definitely. The addition of other elements intended to give extra strength tends to increase friction.

In addition to the direct effect of the rubbing speed on the coefficient of friction, the tests revealed a variation in the friction with the relative sliding velocity of the worm with the wheel. In a worm gear the actual sliding velocity is the algebraic sum of two velocities. The worm slides over the wheel and vice versa, and the ratio of these velocities varies according to the design of the gear. The effect on the coefficient of altering this ratio is seen in Fig. 2. The curves were obtained from mineral oil of the 600 W type, and are

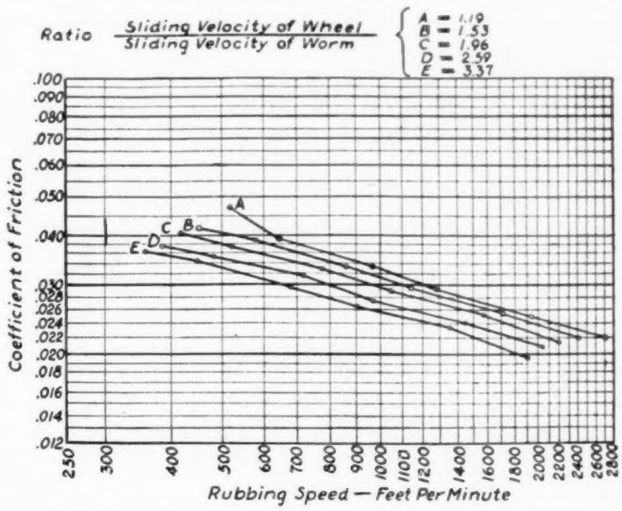


FIG. 2 RATIO OF VELOCITY WITH WHICH WORM SLIDES OVER THE WHEEL (AND VICE VERSA) AS IT AFFECTS THE COEFFICIENT OF FRICTION

typical for this class of lubricant. The ratios of the relative sliding velocities of the wheel and the worm for the various curves are as follows:

$$A = 1.19;\ B = 1.53;\ C = 1.96;\ D = 2.59;\ E = 3.37$$

(H. J. Watson in *Machine Design*, vol. 4, no. 10, Oct., 1932, pp. 31–32 and 72, 4 figs., *ep*)

MACHINE PARTS

Ball Versus Tapered Roller Bearings

IN THIS paper an attempt is made to compare two types of "anti-friction" bearings for the purpose of determining if they are competitive or supplementary; that is, to answer, from an engineering standpoint, the questions: Can either ball or tapered roller bearings be used in each application? Or are there two distinct fields, one where ball and the other where roller bearings should alone be used?

The points on each of which a comparison seems desirable and which are therefore covered in this paper are: dimensions, weight, radial-load capacity, thrust-load capacity, and speed. Other points, which are not covered in great detail but which are mentioned, are lubrication and efficiency. Naval applications in particular were kept in mind throughout.

The author considers the two types of bearings as competitive in the sense that for a certain application either a ball or a tapered roller bearing can be designed and installed and the results will be satisfactory in both cases. On the other hand,

the two types are not competitive but have separate and definite fields of application in that there are preferential uses for the two. This the author shows by two tables which cannot be reproduced here, but which cover (1) the single ball bearing versus the small roller, and (2) the double ball bearing versus the large roller.

Depending on the load, double and single ball bearings should be used in sizes below one inch in cases where the thrust load relative to the radial is not large and in cases where the tendency will be to operate at higher rather than lower speeds than the designed speed.

Depending on the load, large and small tapered roller bearings should be used in sizes of one inch and above in all cases where weight and size are important considerations; in cases where the thrust load relative to the radial load is large; and in cases where the tendency will be to operate at lower rather than higher speeds than the designed speed. (Lt. James E. Hamilton, U.S.N., in *Journal of the American Society of Naval Engineers*, vol. 44, no. 4, November, 1932, pp. 407–428, 11 figs., *e*)

MARINE ENGINEERING (See Power-Plant Engineering: The Benson Land and Marine Boiler)

MOTOR-CAR ENGINEERING

Super-Balloon Tires

TODAY car engineers, because of the appearance of super-balloon tires, are confronted in a particularly bad way with the problems of shimmy, tramp, and wheel kick, and of revised steering, springing, snubbing, weight distribution, and seat-cushion spring rates and deflections. They have to attack these because the customers and the sales department will not forsake the thought of the improved ride they anticipate from super-balloon tires. Moreover, the customer is right, for riding comfort can be improved. Super-balloon tires will be one of the contributing factors to further ride improvement, with the result that a complete car redesign is predicted for the not-far-distant future.

There is no clear definition of a super-balloon tire available today. They are proposed in seven sections, from 6 in. to 9.75 in., and the author gives several tables, including one for loads and inflation for these tires.

Development of the super-balloon tire has not yet progressed sufficiently to claim that its tire-tread life will exceed that of the present standard tire. Because of increased deflection, tire heating causes a more rapid increase in air pressure in super-balloons up to a temperature at which the radiation of heat from the larger exposed tire surface produces an equilibrium of temperature and pressure. The fact that temperature and resulting inflation rise in the super-balloon are rather rapid, means that tire pressures from the viewpoints of riding quality and tire life will not be easy to control.

Had the car manufacturers in the National Automobile Chamber of Commerce and the equipment tire makers recognized the magnitude of the changes that super-balloons may eventually require and the immediate expense of the necessary development work, the movement might have been retarded and adequate time allowed, as in 1923, to work the tire into the design of new cars. Now it is too late for any retardation pressure to become effective. Super-balloons very likely will be standard equipment on some light and medium-weight cars in 1933, unless serious deficiencies develop.

The following matters are discussed by the author in considerable detail: Deceleration, maximum speed, and gasoline consumption (the standard tire is more economical in fuel consumption); shimmy and tramp (new cars can be designed to perform on super-balloon tires as well as or better than on present standard tires, and present model cars can be doctored to perform reasonably); rideability and roadability; steering; quietness of tires; and traction and skidding resistance. Considerable space is devoted to the subject of what may happen following blowouts. The experience of a test driver was that the super-balloon tire when blown out on a front wheel produces a harder pull on the steering wheel toward the side of the blowout than when the standard tire lets go, and that it might be difficult for the average driver to right the car. However, after the steering had been righted, the car control down to a stop seemed easier with a larger tire than with a smaller one.

Cars seem to be more difficult to control when a rear tire blows out than when a front one does. In spite of the hard pull on the steering wheel when a front tire goes down, the driver has definite directional control of steering. He has no such definite control of the rear end of the car with a flat rear tire, and rear-end sway at high speed is controlled with difficulty. (B. J. Lemon, Field Engineer, Tire Development Department, U. S. Rubber Co., Detroit, in *S.A.E. Journal*, vol. 31, no. 4, Oct., 1932, pp. 403–410, 6 figs., and discussion, pp. 410–411, 1 fig., *cdp*)

PETROLEUM ENGINEERING

Thin-Gage Copper as a Wrapper for Protecting Pipe-Line Coating

THE advantages of thin-gage copper as a wrapper for protecting pipe lines against corrosion have been known for a long time, but until recently such copper was not obtainable in widths over 8 in. It is only quite lately that a method has been developed for making thin-gage copper sheet of a minimum thickness of 0.0017 in. (1 oz per sq ft) in continuous lengths up to 48 in. wide. The wrapper takes up the soil stresses and assures that moisture and stray currents will not reach the pipe.

According to a paper presented before the American Petroleum Institute by E. V. Rinehart of the Johns-Manville Corporation, the full effect of the waterproofing qualities of a bituminous material cannot be obtained in underground service unless some means is employed to reinforce it against distortion and abrasion. Quotations from other papers are cited in the original article. (A. L. O'Brien in *The Oil and Gas Journal*, vol. 31, no. 19, Sept. 29, 1932, p. 63, *p*)

Improvements in Pipe-Line Operation

WHILE there has been a marked reduction in pipe-line construction work and in the expansion of pipe-line systems during the last year, the work of maintenance and improvements continues. This applies to increase in research work.

Better pipe is being made now by manufacturers than ever before; the efficiency of all types of engines has been increased through improvements in manufacture made as a result of closer cooperation between maker and user; pumps are better; difficulties in obtaining the exact kind of equipment needed and desired in installation of water-cooling systems have been ironed out and eliminated as engineers of the pipe-line companies and those of manufacturing concerns have studied these problems together; and various other types of equipment

have been made to conform to conditions existing in the pipe-line industry.

These improvements have opened a new era for the pipe-line-company engineer. They permit him now to design a pipe line most applicable to conditions existing in any particular territory, and arrange for the operation of that line in the most economical and efficient manner. With better equipment and more efficient engines, pumps, etc., a pipe line best suited to the needs and requirements of the company can now be designed, constructed, and operated on a basis which will assure the greatest efficiency and economy.

One prominent manufacturer of pipe-line equipment in the East recently told the writer the depression was the best thing that could have happened to his company. "As long as we were selling all we could produce, we had no time to do any research work," he said. "But when the depression hit us and our sales dropped off, we were forced to do extensive research work to find out a lot of things about our own product we did not know and what could be done with this product which we were not doing. As a result we have been able to make such improvements in that product, new fields for sales have been opened, and we now are in a position to actively and successfully compete with products which formerly dominated a certain field of pipe-line activity."

First costs of a pipe line are no longer regarded as the most important factor in consideration of any project. Those costs are now combined with operating expenses over a certain period of time and based on efficiencies obtainable so that total costs of construction and operation over a period of years are balanced against the quantity of products transported and the revenue derived therefrom. Improvements in operating methods and practices and in equipment now permit engineers to make fairly accurate estimates of costs covering a long period of time.

Among other improvements are mentioned installations of high-speed Diesel engines connected to centrifugal pumps with gear increasers; the development of the closed type of water-cooling systems for Diesel engines; and the extensive use of recording instruments and gages of all types.

It has been estimated that in the petroleum industry close to 10,000 miles of pipe line must be replaced or reconditioned annually. The tractor with special types of booms, powered shovels, cleaning, coating, and wrapping machines and other such equipment, has facilitated this work at a lower cost than under former methods, and permits a far better job. After eight years of constant research and work one copper company has perfected a method of making sheet copper in a continuous length, one one-thousandth of an inch thick, at a price which makes it available as a wrapping for pipe lines to protect coatings from soil stress. (Andrew M. Rowley, in *Oil and Gas Journal*, vol. 31, no. 19, Sept. 29, 1932, p. 41, *g*)

The DeLaval Process of Dewaxing Mineral Oils

THE first information about this process was given out at the Congress of Polish Petroleum Technologists in Lwow in 1930. Since that time, however, the process has been extended to the manufacture of automobile and cylinder oils in pipe stills. In this process the oil is mixed in a proper proportion with trichlorethylene, which is said to be particularly suitable for the purpose because of its high specific gravity (1.47), low boiling point (87 C = 188.6 F), and suitable heat capacity and heat of evaporation. Moreover it is a powerful solvent for both oil and wax. As soon as the solution process has been completed, the mass is cooled from about 40 C to —30 C (104 F to —22 F) in from 12 to 15 hr, whereupon the mass is centrifuged and the two components, namely, the dewaxed oil and the deoiled wax, are freed from the trichlorethylene by steam distillation at temperatures of 115 to 118 C (239 to 244.4 F). The centrifugal separators are said to be of a special construction with an output of a maximum of 1200 liters (316.9 gal) per hr.

The original article contains data on test runs with various kinds of oils. One of the advantages claimed for this process is that the solvent is not combustible, which makes it safe from a fire point of view. (N. B. in *Petroleum Zeitschrift*, vol. 28, no. 41, Oct. 12, 1932, pp. 3–5, 1 fig., *d*)

POWER-PLANT ENGINEERING

Solubility of Calcium Sulphate and Calcium Carbonate at Temperatures Between 182 C and 316 C

THIS matter is of importance in connection with the operation of steam boilers. The procedure in the majority of the previous investigations conducted along this line at lower pressures has involved the operation of a small boiler, which meant that much time had to be spent in obtaining equilibrium conditions. In the present investigation a large number of small steel bombs were used for the solubility determination. Four constant-temperature boxes were constructed to hold these bombs. With each box at a different temperature and with six bombs in each box, twenty-four separate solubility tests were run simultaneously, thus obtaining results much more rapidly than was possible by the older procedure.

The results obtained are said to be of high precision and are given in the form of tables and curves. It has been found that the solubility of calcium sulphate decreases with increase of temperature. The solubility of calcium carbonate likewise decreases with increase of temperature, while the solubility of calcium carbonate in the presence of sodium carbonate is quite low (less than 0.01 millimol per liter).

Among other things it has been found that at 182 C and 207 C as the sodium sulphate increases the calcium carbonate increases, so that in the solution of higher sulphate content the calcium is equal to that when calcium sulphate was the solid phase and the sodium sulphate content was high. (F. G. Straub, University of Illinois, in *Industrial and Engineering Chemistry*, vol. 24, no. 8, Aug., 1932, pp. 914–917, 6 figs., *e*. From paper before Division of Industrial and Engineering Chemistry at the meeting of the American Chemical Society, New Orleans, La., Mar. 28–Apr. 1, 1932)

A Molten-Salt Method of Heat Storage and Heat Exchange

ESSENTIALLY this process consists in the use of stable, very high-boiling-point liquid compounds which are used to absorb heat at one point of a setting and deliver it for use at another, the liquid being caused to travel continuously through the circuit by means of a pump. The interest of the present article lies in the fact that it describes a new type of liquid for use in effecting heat storage and exchange, recently placed on the market in Germany and known as the "N.S." molten salts. The inventors are W. Nocon and Ernst Sander, and the salts are manufactured by Heinrich and Holzhüter, of Berlin-Charlottenburg. The salts are a mixture of six parts by weight of aluminum chloride, three parts of sodium chloride, and one part of ferric chloride (Fe_2Cl_6) used in a closed circuit in the absence of air. The mixture apparently softens at about 248 F, melts at about 302 F, and can be used continuously while remaining liquid throughout without

any decomposition at temperatures in excess of 1000 C (1832 F). It is claimed that the salts have no corrosive effect on iron and steel and are entirely incombustible. The specific heat of the compound is very high, about 0.70, and the specific weight, 1.95 to 2.00. The material solidifies without expansion. The increase in volume under high-temperature conditions is said not to exceed about 10 per cent, but further details on this point would seem to be required. It is believed that the salts used in the exact proportions stated above formed a new complex product of unknown composition which decomposes at very high temperatures.

The author compares certain features affecting operation of the salts and such materials as diphenyl and diphenyl oxide alone or mixed with naphthalene. The details of the apparatus with which the specific heat of the salts was determined are given in the original article.

The author discusses the application of the salts to steam superheating and low-temperature carbonization. (David Brownlie in *The Steam Engineer*, vol. 2, no. 2, Nov., 1932, pp. 55–57, 1 fig., *d*)

The Benson Land and Marine Boiler

AFTER giving a brief history of the Benson process, the author refers to the installations at the cable works at Gartenfeld and at the Langerbrugge Station. These have been described previously. It is mentioned that although all Benson boilers so far are oil- or pulverized-coal fired, chain-grate stokers are contemplated for future installations, and the original article shows a detailed design for such a boiler.

In the marine field the installation of the Benson boiler on the steamer *Uckermark* is described and the layout illustrated. The most interesting part of the paper is that dealing with the experiences. Although in the first two test installations (Rugby and Siemensstadt) good results were obtained with plain carbon steel, it was later decided to use, at least for the tubes exposed to radiation, a 3 to 5 per cent nickel steel. Still later a steel with a certain content of carbon, manganese, and molybdenum was used with good results.

The coils constituting the heating surfaces are manufactured from standard straight tubes by cold bending and welding. The number of detachable connections is reduced to a minimum. Because of possibilities of unusually high pressure in connection with sudden temperature changes due to the quick starting and stopping of the Benson boiler, new designs had to be provided for all the flanges, gaskets, bolts, and washers. Special reference is made to the metal lenses, ultimately found to be the best solution, and to the spring washers necessary to compensate for changes in length of flange and bolt.

Fig. 3 illustrates an overflow regulating valve which is one of the new designs that had to be developed for use in Benson installations. They are all angle valves manufactured from solid blocks of steel, and are unbalanced on account of the small dimensions. The original article also shows a high-pressure stop valve.

The matter of feedwater is discussed in considerable detail, and the feed pumps described.

The Benson boilers are generally operated from a single control room by remote control. The speeds of the feed pumps, fans, and coal feeders, and the positions of the important valves, are controlled by push buttons or automatically. The original article shows the Siemens automatic pressure and temperature controller and charts of test results.

In the first commercial installations, efficiencies as high as 84 to 86 per cent were obtained, whereas on a test boiler at the Technical High School in Charlottenburg 83 to 84 per cent was reached. At the Langerbrugge Station the average efficiency figures available are around 81 per cent, but these efficiencies were gained at highly varying loads and with coal of very high ash content. The efficiency of the Benson marine boiler on board the *Uckermark* as measured was 89 per cent.

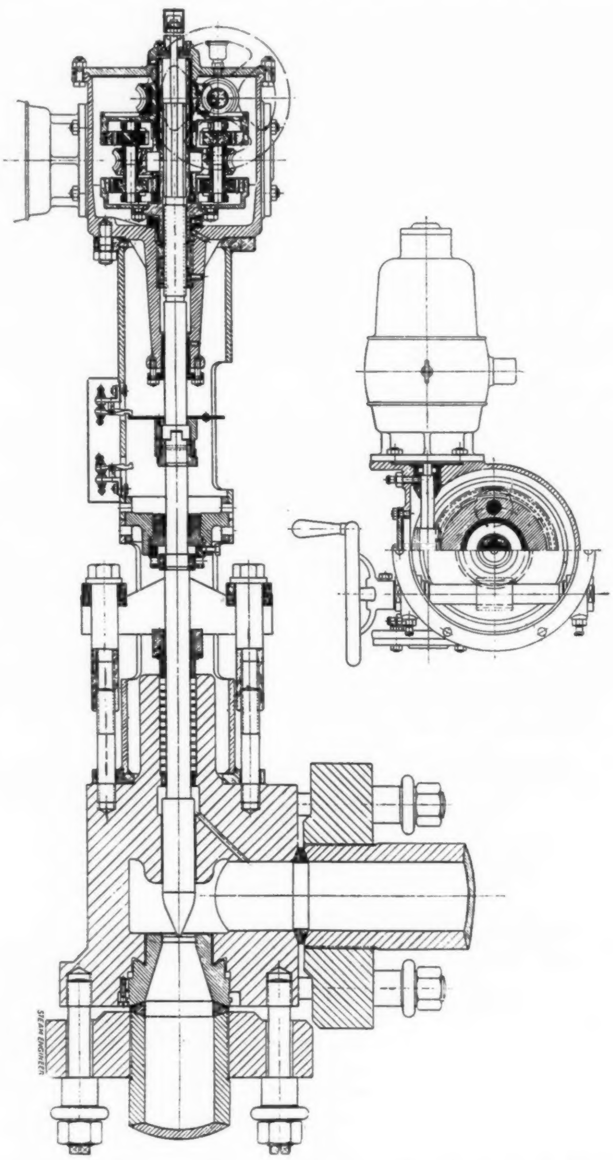


FIG. 3 HIGH-PRESSURE REGULATING VALVE FOR THE BENSON BOILER

It is said that the price of the Benson boiler is not higher than that of a normal 500-lb-pressure unit of the same size. (Paper read by F. Ohlmüller, Chief Engineer of the Siemens-Schuckertwerke Co. in Berlin, at the Engineers' German Circle, London, Oct. 10, 1932; reported from translation published in *The Steam Engineer*, vol. 2, no. 2, Nov., 1932, pp. 64–71, 9 figs., *d*)

The Zoelly High-Performance Steam Generator

THE characteristic feature of the Zoelly boiler is that steam is generated in tubes either conically shaped or else expanded by stages from bottom to top. The feedwater is sup-

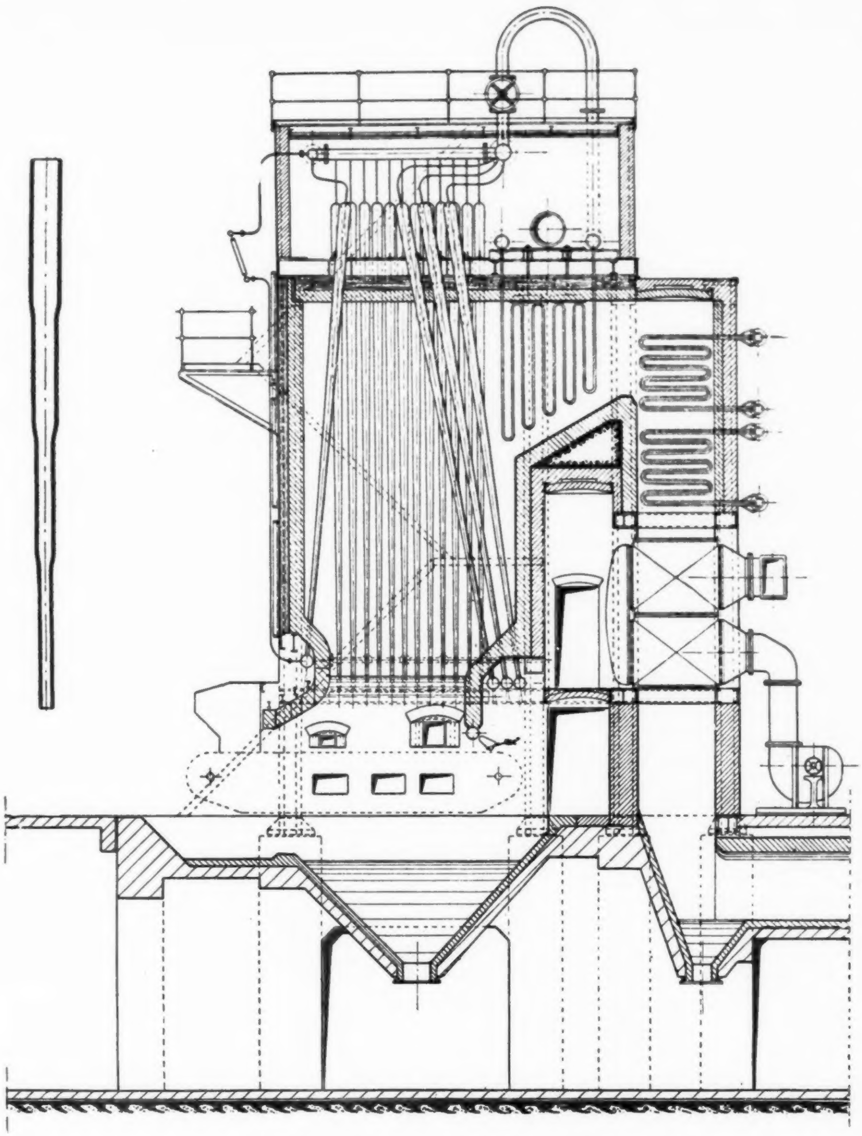


FIG. 4 THE ZOELLY STEAM GENERATOR

[*Left* (at top), Zoelly stepped-diameter evaporator tube. *Right*, Zoelly boiler for 100 atm gage pressure and 450 C (842 F) steam temperature.]

plied to these tubes from the bottom and evaporated without any forced circulation. It is claimed that a high factor of safety is secured in the new steam generator as a result of the employment of evaporator tubes that are safe in themselves. A section of such a tube is shown in Fig. 4; only tubes in which the cross-sections expand by stages are used, since for practical reasons conical tubes cannot be made. [Conical tubes of fairly large diameter were made in the United States during the war for periscopes of submarines by centrifugal casting. Whether the same method is applicable to the production of small-diameter tubes has not been established.—EDITOR.] The tubes are seamless drawn, made of a special high-strength steel, and the wall thicknesses are so proportioned that with the gage pressure prevailing on the inside of the tube and the maximum heat load there should be a factor of safety of at least 1.8. The stages for various operating pressures are all of the same length but differ in their diameter ratios.

An illustration (Fig. 2) in the original article shows the stresses occurring in the tubes of the boiler as a function of the heat load. It is stated that no serious trouble was experienced in generating steam in the stepped tubes in question, as shown by curves plotted from actual measurements. It is particularly emphasized that, notwithstanding the fact that all regulation was done by hand, there was no boiling over of the boiler. Furthermore, it is said that the Zoelly steam generator, which operates without either natural or artificial circulation, shows that the higher the steam pressure the quieter is the surface of the water level, and the greater the evaporative output the lower the moisture content of the steam. Even with artificially produced variations in load, the water surface remained perfectly quiet. With transient evaporative rates of 400 kg per sq m per hr and over, the moisture content as determined by a throttling calorimeter did not exceed 3 per cent. The unusually high rates of evaporation from the heating surfaces are believed to be due to the favorable heat transfer, which in turn is due to the fact that the bubbles of steam forming in the course of steam generation and rising vertically are immediately permitted to escape. In doing so they have to overcome only a minimum resistance, because of the progressively enlarging cross-sections of the tubes. It is this fact that lies at the basis of the design of the Zoelly stepped-tube boiler. Another important advantage in the direction of increase in safety of operation is said to consist in the employment of only vertical or nearly vertical tubes. Bent tubes, if not sufficiently cooled, always constitute a source of danger, because the steam bubbles which settle on the curved portions of the tubes in cases of insufficient water circulation tend to produce overheating and may result in bellying out and rupturing the tubes. Tests made on the test stand by Escher, Wyss & Co. have shown that the Zoelly tubes are free from this possible source of danger. This again is due to the fact that the expanding cross-sections of the evaporator tubes provide a quick and certain way for the steam bubbles to rise, which makes possible also a thoroughly reliable cooling of the inner walls of the tubes.

A further reason for the high safety of operation of the boiler lies in its comparatively limited water content. This has a further advantage in that it reduces the time required to heat up and permits a very close regulation and control of the water level. Notwithstanding its small water content, the boiler has a certain reserve capacity. This is due to the fact that the boiler can deliver through a drop in pressure and without change of fuel supply more steam from the water that it contains, than corresponds to the natural balance between grate load and steam generation.

Fig. 4 shows a section of a Zoelly steam generator designed

with present-day ideas in mind as to an organic connection between boiler and furnace and to the utilization of heat radiation. The boiler is intended for a production of 15,000 kg (33,000 lb) per hr at 100 atm gage pressure and 450 C temperature (842 F). It is designed as a pure radiation type, which has the advantage of reducing the floor space required and making all parts easily accessible. The evaporator tubes can be easily taken out and new ones substituted. The feedwater flows through a preheater consisting of a number of heat-exchanger tubes and collectors. It then goes into the main feedwater pipes, which are provided with the usual valves. It does not appear that the boiler illustrated has as yet been built. It is claimed that the new boiler is low in first cost, light in weight, and that its floor-space requirements are limited.

It is stated that a Zoelly steam generator for 100 atm gage pressure and 450 C (842 F) need not cost any more than a boiler of conventional design built for 20 atm gage pressure and 450 C (842 F) temperature. (H. Wesche in *Die Waerme*, vol. 55, no. 43, Oct. 22, 1932, pp. 733–735, 4 figs., *d*)

THERMODYNAMICS

Thermodynamics of a Gas-Turbine Aggregate

A NEW method of computation of a gas-steam compressor for a constant-pressure gas turbine with water injection has been developed by the author on the basis of a new *i/x* diagram. The author claims that the slow development of the gas turbine as compared with the steam turbine has been due to the difficulty of handling the high temperatures of combustion in the former with our present engineering materials. The following means have been resorted to in order to lower the excessively high temperatures: First, combustion of the fuel, such as gas and oil, with an excess of air; second, external cooling of the turbine housing; third, internal cooling of the turbine blades; fourth, water injection into the combustion space; and fifth, a combination of the above-listed methods.

Economically the problem of the gas turbine—which means attainment of a total efficiency of 36 per cent, equal to the efficiency of the Diesel engine—depends on the solution of the problem of employing a minimum of work of compression in the handling of the air of combustion. This work of compression may run as high as two-thirds of the total useful work, while the work required for the compression of the fuel is comparatively small, and that for handling the injection water may be neglected entirely.

The compression process for the gaseous fuel in combination with the injection water raises problems of thermodynamic interest in the field of mixtures of two materials. Mollier was the first to develop an *i/x* diagram for air-water mixtures at atmospheric pressure. Merkel built upon it the thermodynamics of drying, while Bosnjakovic devoted his attention to other mixtures of two materials. In gas-turbine design the *i/x* diagram for gas-water mixtures at any pressure may be employed very profitably.

To maintain a proper process of combustion in a gas turbine it is important that the water vapor should be present in the gas in a state of maximum possible subdivision, as this improves the cooling action of the water vapor on the gas. Had it been possible to find a commercially feasibly process for compressing water with gas in approximately the molecular state for the former, the cooling action of the water would have been still greater because of its enormous surface. This would make it possible to reduce the amount of water injection and simultaneously obtain the same amount of cooling, and hence a higher degree of efficiency of the gas turbine. Work along this line is proceeding.

Fig. 5 shows the *i/x* diagram for a mixture of illuminating

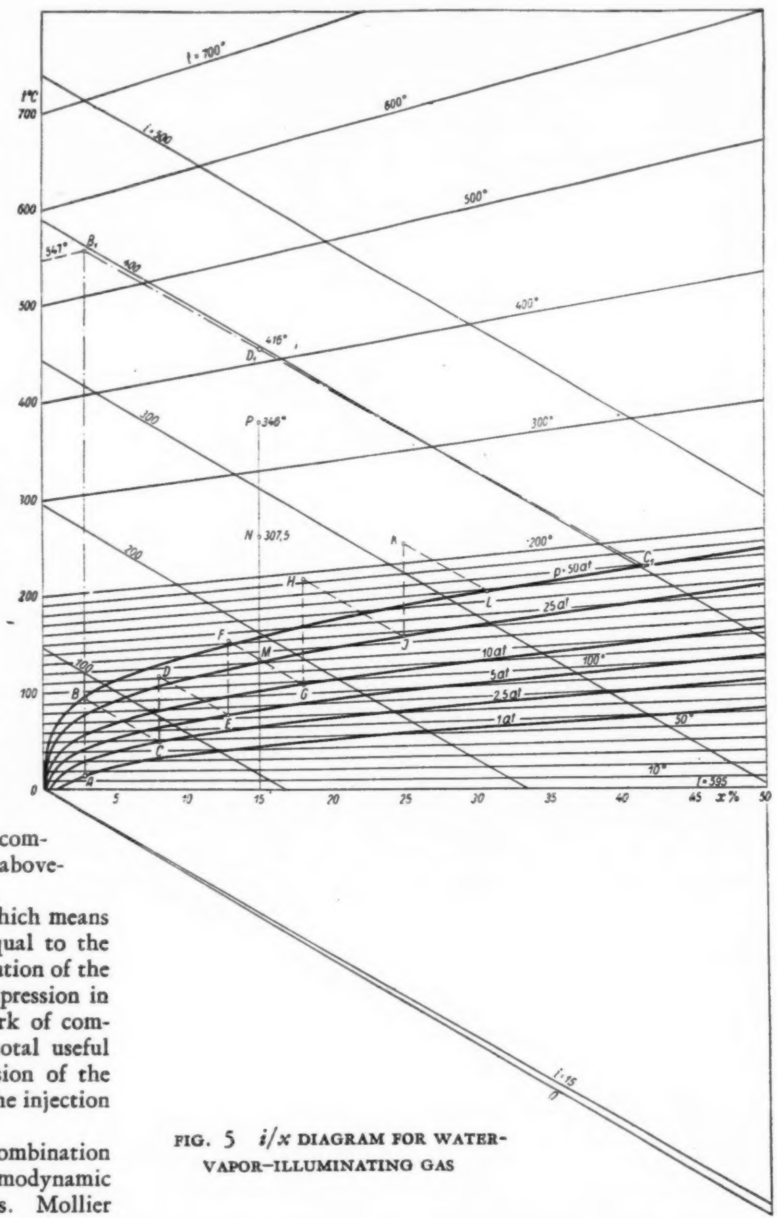


FIG. 5 *i/x* DIAGRAM FOR WATER-VAPOR–ILLUMINATING GAS

gas and water vapor for total pressures p_0 up to 50 atm, neglecting the fog isotherms which are different for each pressure and form the partition line between the water and vapor state. This is done because in this particular connection these isotherms are not needed. The processes occurring in a gas-water vapor compressor can now be studied by means of this new diagram.

It is assumed that a five-stage turbo-compressor is used.

(*a*) If the amount (x kg) of water injected is arbitrarily selected and the value is taken from the i/x diagram for 1 kg of gas with an initial pressure of $p_1 = 1$ atm and $t_1 = 15$ C (point A), the illuminating gas will be found to be capable of taking up 0.03 kg of water vapor in a stage of saturation. It is immaterial in this connection whether we inject this amount of water in a single batch or in several stages. From a practical point of view the former would be done, however. The excess of water will be compressed with the gas stage by stage, and the work expended for this purpose is practically equal to zero. Only enough water will be added in each stage to produce evaporation at the end of compression in that stage. One may imagine that the process proceeds in such a manner that compression takes place adiabatically without external cooling and the heat of compression is in part abstracted from the gas by the water, so that at the end of the process a lower temperature prevails than the one corresponding to the adiabatic. Practically, however, polytropic compression takes place. The presumed but never actually attained end temperature of adiabatic compression gives, assuming constant $x = 0.03$, the point B on the diagram, and can be calculated from the following equation:

$$T_2 = T_1\left(\frac{p_2}{p_1}\right)^{\frac{K-1}{k}}$$

If one draws through point B a parallel to the straight line $i = 15$, it will cut the saturation curve of 2.5 atm at C. The exponent in the compression formula $k = c_{pm}/c_{vm}$ must be determined for the mixture varying from stage to stage by the laws of mixtures. The partial pressures p_D or p_G of the constituents of the mixture vary according to Dalton's law according to their partial volumes r_D or r_G, and were found to be

$$p_D = \frac{\psi}{1+\psi} \times p_0, \quad \text{and} \quad p_G = \frac{1}{1+\psi} \times p_0$$

where

$$\frac{p_D}{p_G} = \frac{x \times R_D}{m \times R_G}$$

these equations having been developed according to a treatise by Ostertag ("Entropiediagramme der Verbrennungsmotoren," 2nd edition, p. 756).

In this case with m as the molecular weight the following expressions have been found: The gas constant is $R = 848/m$, so that R_D is $848/18 = 47.1$, and $R_G = 848/11 = 77.1$, while the m in the preceding expression = 1 kg of gas. Hence, at the initial state in the compressor $p_D = 0.018$ and $p_G = 0.982$ atm, making a total of 1 atm. With $r_D = 0.018$ and $r_G = 0.982$ [It is not clear whether the author means here r_D and r_G as he states, or p_D and p_G—ED.] and the specific heat for one molecule, it is found that $c_{pm} = 0.67$, and since $c_{vm} = c_{pm} = 0.67$, and $c_{vm} = c_{pm} - \dfrac{1.987}{\Sigma(r_i \times M_i)} = 0.4914$, it will be found that $k = 1.364$. This gives $t_2 = 94$ C (point B).

If now point C ($t_p = 48.5$ C; $x = 0.081$) represents the end point of the actual compression in the first stage, the process of compression may be thought of as if the passage were directly made from state A to state C. This corresponds to a polytropic compression with a considerable approximation to the isothermal.

In order to determine the polytropic work between $A(P_1, V_1, T_1)$ and $C(P_2, V_2, T_p)$, namely,

$$AL = A \times P_1 \times V_1 \times \frac{1}{n-1} \times \left(\frac{T_p}{T_1} - 1\right)$$

it is necessary to know the polytropic exponent n. This is obtained by taking the polytropic equation

$$\frac{T_p}{T_1} = \left(\frac{p_2}{p_1}\right)^{\frac{n-1}{n}}$$

and substituting therein

$$y = \frac{n-1}{n}, \qquad y = \frac{\log \dfrac{T_p}{T_1}}{\log \dfrac{p_2}{p_1}}, \qquad \text{and } n = \frac{1}{1-y}$$

In this case $n = 1.1348$.

AL consists of the work of compression of the gas AL_G and the work of compression of the water vapor AL_D.

The magnitudes of the equal volumes which are required are determined by the gas equation to be as follows:

$$V_{1G} = \frac{G \times R_G \times T_1}{P_{1G}} = 2.261 \text{ cu m}$$

and

$$V_{1D} = \frac{x \times R_D \times T_1}{P_{1D}} = 2.261 \text{ cu m}$$

but $AL_G = 44.4$ and $AL_D = 0.814$, or in all 45.214 kg-cal. This calculation may be applied with proper modifications to the computation of the other four stages of the compressor. (See Table 1 of the original article.) To this must be added the quantities of heat delivered to the water, namely, $Q = \dfrac{k-n}{k-1} \times AL$. In the diagram the line $ABCD$ is extended to L. The terminal content of water vapor is found to be $x = 0.308$ from the diagram, and shows the considerable lowering of the efficiency of the gas turbine.

(*b*) The advantages of multi-stage compressors appear from a comparison with the results obtained with the single-stage compressor under the same initial conditions (Table 2). In the diagram this is shown by lines AB_1C_1. In practice, however, compression from 1 to 50 atm in a single stage is not feasible.

(*c*) If, however, a definite maximum amount of water vapor, for example, $x = 0.15$ kg, is admitted, a higher efficiency of the aggregate becomes possible. In the diagram the compression process for the stages I (ABC) and II (CDE) is the same, but in stage III the process does not go on as hitherto as indicated by lines EFG, but ends between F and G in M on the line $x = 0.15$. Because of this the end temperature of the polytrope is $t_p = 123$ C. The stages IV and V, because of the fact that x = constant = 0.15, must show purely adiabatic characteristics and have as end points N and P, with temperatures substantially higher than before. This is shown in Table 3 in the original article.

(*d*) If we cut off the polytrope of a single-stage compressor such as has been considered under (*b*) also at $x = 0.15$ (point D_1), we obtain an end temperature $t_p = 416$ C. (Table 4 in the original article.) The saving in the work of compression for $x_{max} = 0.15$ with a five-stage compressor as compared with a single-stage compressor is 38.23 kg-cal. In order to establish eventually a basis for comparison for the various shares of performance of the aggregate, it will be arbitrarily assumed that at $x_{max} = 0.15$ the amount of fuel B is 1 kg of illuminating gas per hr. The indicated output of a gas-water vapor compressor, assuming a high value ($\eta_k = 0.7$) for the efficiency, is

$$N_K = \frac{AL \times 427 \times B}{3600 \times 75 \times \eta_k} = 0.578 \text{ hp (metric)}$$

It might be mentioned that at pressures in excess of 25 atm the gas law no longer applies precisely. The compressor for the air of the combustion has no new features thermodynamically. Its output, however, is of the utmost importance for the total efficiency of the aggregate. If we assume polytropic compression of air from 1 atm at 15 C with water cooling through the compressor walls to a pressure of 50 atm in such a manner that exactly the same end temperature $t_2 = 346$ C is attained as given in case (*c*), then the work of compression is

$$AL = \frac{A \times G_L \times R_L}{n - 1} \times (t_2 - t_1)$$

The minimum amount of air G_L for various degrees of excess of air λ can be determined by means of chemical equations for combustion. The indicated output is therefore

$$N_L = \frac{AL \times 427 \times B}{3600 \times 75 \times \eta_k} = 2.345 \text{ hp (metric) when } \lambda = 1$$

for larger values of λ, G_L, AL, and N_L increase in direct proportion to λ when η_k is 0.7.

The combustion at constant pressure with the partial pressure of the gas 49.53 and of the water vapor 0.47 gives the following temperature of combustion:

$$t = \frac{H_{u\,(\mathrm{Mol})} + t_1 \times \Sigma\,(V' \times [C_p]_0^{t_1})}{\Sigma\,(V'' \times [C_p]_0^{t})} = 2261 \text{ deg when } \lambda = 1$$

Here $t_1 = 346$ C is the temperature of gas and air before combustion; V' volumes of the individual gases before combustion, and V'' their volumes after combustion.

$$H_{u\,(\mathrm{Mol})} = 24 \times H_{u\,(\mathrm{nm}^3)} = 24 \times 3900 = 93{,}700 \text{ kg-cal/Mol}$$

At this inadmissibly high temperature, carbon dioxide and water begin to break up, producing incomplete combustion. For a value of λ from 1.5 to 2, t is 1713 or 1368 C. It is only the lower of these temperatures that can be had or used in practice. Gases at 1368 C and water vapor at 346 C take a temperature of mixture of

$$t_m = \frac{G_V \times C_{pV} \times t + G_D \times C_{pD} \times t_D}{(G_V + G_D) \times C_{pm}} = 1362.2 \text{ deg}$$

The difference between t_m and t is here very small, which is due to the presence of large amounts of air and comparatively small amounts of water mixture. Table 5 in the original article gives the data for the various coefficients of excess of air. It is not reproduced here because of lack of space. From this the author proceeds to the development of a formula for the output of a constant-pressure gas turbine with water injection and excess air. In the course of this discussion he gives a formula for the gas constant of the gases of combustion and determines the heat drop. He proceeds next to the consideration of the efficiency of a gas turbine. If both compressors are directly driven from the gas turbine, the thermodynamic efficiency of the turbine is determined by

$$\eta_G = \frac{N'_T - N_K - N_L}{H_u \times B_T} \times 632 \text{ in hp (metric)}$$

where $B_T = 1$ kg of illuminating gas per hr, whereof the lower heat value $H'_u = 3900$ kg-cal per n cu m equivalent to 8520 kg-cal per kg. Because of the high temperatures, only the values $\lambda = 2$ and $\eta_G = 0.2595$ are used. This efficiency is far below that of a Diesel engine, which is due to large excess of air. As has been pointed out above, savings must be achieved, as in case $\lambda = 2$, it amounts to as much as 53.4 per cent of the effective output. It is therefore recommended to either compress the air isothermally instead of polytropically as by this N_L for a value of $\lambda = 2$ is reduced from 4.69 hp to 3.86, or else to connect the air and gas compressor not directly with the gas turbine but with the Diesel-engine drive. In such a case we shall have

$$\eta_G = \frac{N_T \times 632}{B_T \times H_u \times B_K \times h_u}$$

Here $H_u = 10{,}100$ kg-cal per kg, which is the lower value of Diesel-engine fuel, and B_K is the fuel consumption in a Diesel engine in kg per hr, which can be calculated by multi-

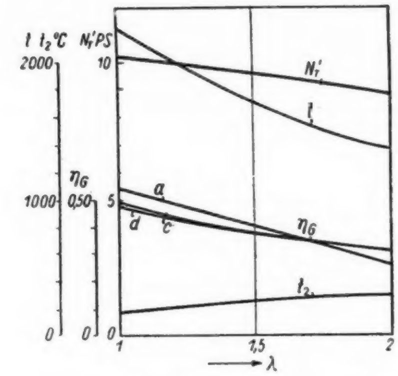


FIG. 6 TEMPERATURES, OUTPUT, AND EFFICIENCY OF GAS TURBINE AS FUNCTIONS OF EXCESS OF AIR

plying the specific fuel consumption of about 0.174 kg per hp-hr by $(N_K + N_L)$. From this it follows that η_G has values of 0.474, 0.382, and 0.3115, respectively, for values of $\lambda = 1$, 1.5, and 2. It is also possible to couple the turbo-compressor for gas and water vapor directly to the turbine, but drive the reciprocating air compressor from a Diesel engine. In this case the formula for the efficiency of the gas turbine is

$$\eta_G = \frac{N_T - N_K}{B_T \times H_u + B_L \times h_u} \times 632$$

and the corresponding numerical values are 0.4825, 0.3842, and 0.3085 for values of $\lambda = 1$, 1.5, and 2. In conclusion, it may be stated that in practice the gas turbine cannot as yet reach the efficiency of the Diesel engine, because the share of work consumed by the air compressor is still quite large. It is, as yet, impossible to get rid of an excess of air equal at least to $\lambda = 2$, and further, the thermodynamic efficiency of the gas turbine as indicated by present experience has not yet reached that of a good steam turbine. The author considers as the most promising arrangement one wherein the compressors are driven by a Diesel engine, or the arrangement wherein only the air compressor is driven by the Diesel engine.

Fig. 6 shows experimental data relating to the combustion temperature t, temperature at the end of expansion t_2, turbine output N_T, and efficiency η_G, all represented as functions of the excess of air λ and showing that for practical purposes one has to operate with a large excess of air. (Dr. of Engrg. Hans Kirst, in *Die Waerme*, vol. 55, no. 36, Sept. 3, 1932, pp. 605–609, *teA*)

SYNOPSES OF A.S.M.E. PAPERS

(Available Upon Request)

MIMEOGRAPHED or printed copies of the papers abstracted on this and the following pages may be obtained, until the supply is exhausted, by addressing the Secretary of the A.S.M.E., 29 West 39th Street, New York, N. Y.

Standards of Qualifications for Engineers

IN THE first part of his paper the author endeavors to point out that the training and experience of the engineer should lead him to take a more active part in national life and assume greater leadership responsibilities. In the second part he discusses the work that is being done in the various provinces of Canada by engineering associations to bring about the enactment of suitable engineers' registration laws.

Not until after the war, the author states, did engineers in Canada actively endeavor to give a real standing to their profession. The Engineering Institute of Canada, a nation-wide organization, embracing all types of engineers in its membership, undertook to give the question of regulating the profession serious thought, and for this purpose devoted the time of several meetings to evolve an act that they hoped would be taken under consideration by the various provinces. This movement met with extraordinary success. Eight of the nine provinces have had Professional Engineers' Acts placed upon their statute books within a few years. These regulations are compulsory at the present time in all provinces except Ontario. The only remaining province, Prince Edward Island, is entirely agricultural, and has a population of about 86,000 which includes very few engineers.

It is necessary to have a definition for a "professional engineer," and this is the most difficult part of the problem. Quebec has obviated this by adopting the name "civil engineer," which, embracing all forms of engineering except that of a purely military character, has been considered to be a profession for 60 years at least.

The Ontario act has been on the statutes since 1922, but it has the weakness of voluntary organization. It is not necessary for an engineer to register if he prefers not to, and as long as he does not call himself a professional engineer, there is no way of preventing him from practicing as from a professional engineer.

The Ontario Association during the past year redrafted its act so as to make it conform with the acts in the other provinces whereby registration became compulsory. In spite of the fact that the various branches of engineering affected were consulted and the legislative committee of the Ontario Association felt reasonably assured that all objections had been met, the revised act did not pass the Private Bills Committee due to opposition from the mining industry.

It has been suggested that the various professional engineering associations make it possible for all third-year and fourth-year students in applied science to become student members of the professional association. This would enable the students to realize the objects of the association and the necessity for their becoming members as soon after graduation as they are qualified.

Ontario is the largest province of Canada with respect to population. It spends more money on engineering projects than all the other provinces put together. If the public were thoroughly informed as to the aims and objects of the Association of Professional Engineers of this province, they would insist on legislation being enacted for their own protection as well as for that of the engineers

The present situation may be summed up as follows: In Quebec, British Columbia, and in the maritime and prairie provinces where compulsory registration is enforced, the acts are working out in a very satisfactory manner. The situation in Ontario is unsatisfactory, and until the government will consent to pass an act with compulsory registration within reasonable limits, progress will be retarded.

No province that has enacted registration laws has rescinded or restricted the scope of its act since it was first passed. On the other hand, the tendency has been to amend the act to make it more rigid. The constitutionality of the various acts has been tried out in one or two instances with satisfactory results, and this situation will be very much strengthened when a proper definition of "professional engineer" can be mutually agreed on by a representative body like the A.S.M.E. and affiliated associations in the United States.

Employers of engineers are paying more attention to the importance of employing registered engineers as time goes on. Criticism of registration comes largely from incompetent and unqualified engineers and industrial interests who fear that their expenses would be increased or their scope restricted by the activities of fully qualified registered engineers.

The paper includes a table setting forth the status of Professional Engineers' Acts in the various provinces of Canada as of May, 1932, and notes on legislation activities since 1928. (Mimeographed paper, by Col. Ibbotson Leonard.)

OIL AND GAS POWER

Heating Fuels for Injection Engines

THREE reasons are given for the heating of fuels for injection engines. These are: To reduce the viscosity of the fuel so that it may be handled by the fuel-injection system; to overcome the ignition lag by heating to such a temperature that the fuel will ignite upon contact with air; and to heat the fuel so that it is effectively a gas on injection and may burn directly and rapidly without the delays of drop transformation. The heating of fuels is worthy of study, and processes of fuel preparation involving heating are almost within reach. Coal will be used in Diesels, after some sort of processing, and when that time inevitably comes, with a development in the use of fuel growing out of the improvements in the use of oil in Diesels, there should be a material increase in the size of internal-combustion engines and the extent of their use. The self-ignition process will receive early development. The preatomization process should be capable of use

without great difficulty for certain fuels and in certain places. Gasoline-injection engines recommend themselves for use where greater efficiency through higher compression ratios is desirable. The processes outlined by the author avoid detonation and save the use of dopes. (Mimeographed paper, by E. A. Richardson.)

Fuel-Injection Engines With Subdivided Combustion Chamber and Heat Accumulator

OPERATION of airless-injection Diesel engines by a new method subdivides the compression space, the greater part being outside the cylinder contour. This part may have a heat-accumulating body. Injection of fuel into this space occurs shortly before dead center. The air displaced from the cylinder is so guided that it provides energetic turbulence in the space where the fuel is being injected. The fuel therefore uniformly penetrates the available air supply, favoring quick ignition and complete combustion. (Mimeographed paper, by Prof.-Dr. Kurt Neumann.)

Surface-Volume Ratio as a Critical Factor in Automotive Diesel Combustion Chambers

CONSIDERING the surface-volume ratio of Diesel-engine combustion chambers as a function of cylinder bore, it appears that the automotive Diesel engine is in a distinct class from the larger Diesel engines from which it was developed. The Diesel engine has long been proclaimed as the most advanced type of internal-combustion motor, but the principal demand for automotive prime movers is still being met by engines other than the Diesel. The large ratio of surface to volume in the small-bore Diesel engine required for automotive work is held largely responsible. Progress has been made in overcoming the small-chamber handicap by subdividing it and making it work as a heat accumulator rather than as a heat dissipator. (Mimeographed paper, by Julius Kuttner.)

RESEARCH

Once-Through Series Boiler for 1500 to 5000 Lb Pressure

THIS paper covers the development of series-type boilers from the early stages which resulted in the Calumet steaming-economizer type now in extensive use to the once-through series boiler. It describes the operation of the latter units from 1500 to 5000 lb per sq in., and test data are given. The limiting factors of this type of unit, such as equalization of flow control with variable capacity, and operation, are discussed. Heat-transfer data on high-pressure superheated steam are presented. (Paper No. RP-54-1a, by H. J. Kerr.)

Characteristics of a High-Pressure Series Steam Generator

THE steam generator dealt with consists of two parallel circuits of seamless-steel tubing supplied with feedwater at one end, and delivering steam from the other end at any desired pressure up to 3500 lb per sq in. and at a maximum temperature of 830 F. The changes which take place in the circuit are measured by means of thermocouples and manifolded pressure connections. The unit is controlled automatically by a system which uses the Thyratron vacuum-tube circuit. A set of charts is presented showing the operation of the automatic control on a swinging load. The tests reported in the paper indicate the effect of (*a*) varying the steaming capacity at constant pressure and temperature, (*b*) changing the pressure at constant capacity and temperature, and (*c*) increasing the steam temperature at constant capacity and two different pressures. The temperature and the pressure changes through the water and steam circuit are shown graphically. Data are also presented on the heat-transfer rates through the furnace-wall tubes. The results up to date indicate that this steam generator will operate successfully at any pressure between 1500 and 3500 lb per sq in. and at a maximum temperature which is limited by the materials used. Automatic control held the steam pressure and temperature nearly constant throughout the range of operation. (Paper No. RP-54-1b, by A. A. Potter, H. L. Solberg, and G. A. Hawkins.)

Economic Life of Equipment

THE correct solution of the problems of how to select and when to replace equipment is vital to industry. In fact, it revolves about the larger problem of how to invest economically and profitably the capital resources of any enterprise. Many rule-of-thumb as well as a number of somewhat more exact methods are now being employed as a basis for determining equipment policies; however, no one of them is suitably adapted to the present needs of industrial executives, process engineers, plant managers, and sales executives. Accordingly the A.S.M.E. sponsored a research project to investigate thoroughly this subject and formulate the principles upon which any equipment policy should be based, and out of which practical technique can be evolved for the ordinary purposes of industry. As a result, this paper, which constitutes the formal report on the project, presents criteria for the economic or useful life of equipment, for the determination of depreciation policies, for the ultimate ability of equipment to produce earnings or profits, for protection from the hazard of impending obsolescence, and for the guidance of equipment manufacturers in the evolution of new designs and in anticipating the needs of industry. All of these criteria depend upon the relative economic superiority of some proposed type of equipment over some equivalent existing type or one chosen as a standard of comparison, and the evaluation of each can be achieved through formulas which are equally applicable to machine tools, jigs and fixtures, labor-saving or material-handling devices, process and power equipment, and even buildings or structures. Moreover, in the course of the investigations, many other important facts were discovered which relate to financial policies, accounting practice, the origin and proper methods of treating overhead, plant layout, maintenance, productivity and idle time, salvage and resale policies, machine design, and, in general, the earning power of the enterprise; all of which are discussed in detail. (Paper No. RP-54-2, by H. O. Vorlander and F. E. Raymond.)

A Study of Primary Metering Elements in 3-In. Pipe

THIS paper presents part of the results of a study of the performance of a complete series of primary metering devices in a 3-in. pipe line. The devices tested were as follows: Three types of orifices (concentric, eccentric, and segmental) with diameter ratios varying from 20 to 90 per cent; flow nozzles with diameter ratios varying from 30 to 88 per cent; also two venturi tubes with three throat sections each, with diameter ratios varying from 33 to 50 per cent. Discharge coefficients are given for these elements, using water as the metered fluid, with a wide range of differential heads. Coefficients are given also on some of the elements where superheated steam at various temperatures was the metered fluid. The effect of sharpness of orifice edge, of roughness of approach pipe, and of surface finish of flow nozzle on water coefficients

is shown. The effect of temperature upon the diameter of the primary device and upon the coefficient of discharge for steam is also given. (Paper No. RP-54-3, by S. R. Beitler, Paul Buchler, and T. C. Barnes, Jr.)

Foaming and Priming of Boiler Water

A RAPIDLY increasing interest in the subject of the foaming and priming of boiler water is shown by the fact that as many papers have appeared during the last three or four years as in the preceding 20 or 30 years. New information about the behavior of suspended solids and of dissolved salts has been brought out, and a helpful theory of foam formation has also been advanced. It would be inferred from recent work that too broad generalizations in regard to foaming and priming of boiler water should not be made, because in some cases the design of the boiler profoundly affects the behavior of the water. (Paper No. RP-54-5, by C. W. Foulk.)

The Elements of Milling

THIS paper presents the results of laboratory milling tests on a variety of materials, using a pendulum-actuated single-tooth milling dynamometer. Tools of various widths having front-rake angles of 15 deg, but no side-rake or helix angles, were used. Tests were run both dry and with a number of cutting fluids. Except where deliberately allowed to dull, the cutters were considered sharp at all times.

The cutting was done with the cutter rotating in a plane perpendicular to the surface of the work, and in all cases data for two fundamental methods of cutting are shown: first, milling up in the regular way with the work being fed into the cutter, and second, milling down with the work fed with the cutter. In nearly all cases a difference in energy is found between these two methods of cutting.

Data giving the energy in foot-pounds necessary to remove a single chip are shown for thirteen widely different materials with constant feed and various values of depth, and then with constant depth and various values of feed. Several different cutting fluids were used. These data are plotted and energy equations are derived for each material, of the form $E = Cwf^x d^y$, where E is the energy in foot-pounds per chip, C a constant for the specific condition, w the width of the cutter in inches, f the feed in inches, and d the depth of cut in inches. Values of the constants are given. Corresponding formulas and values for the horsepower per cubic inch per minute are also given. No two materials give the same values of the exponents for the feed and depth variables.

Data are also shown for milling with the cutter in the sharp, dull, and very dull conditions, to determine the effect of the sharpness of the tool on the milling-energy formulas. It is found that dulling does change the formula, but has greater effect on feed than on depth of cut.

Milling-energy data are also presented for a large variety of materials when the cut was held constant at 0.125 in. depth, 0.010 in. feed, and the cutter was 0.250 in. wide and had a 15-deg front-rake angle, in order to compare these materials from a milling-energy standpoint. It is concluded that there is no way, other than actual test, to determine the milling properties of a material.

A discussion of previous milling papers has been added, and an analysis of the form of a milling chip is presented. It is concluded from this analysis that, theoretically, the coarse-tooth cutter is better than the fine-tooth cutter, when milling up, keeping the linear feed per tooth constant. When milling down, however, the fine-tooth cutter removes a chip of greater average thickness than the coarse-tooth cutter, and consequently is considered to be more efficient from a power standpoint when diameter and feed per tooth are constant.

The fine-tooth cutter cutting down produces the greatest average thickness of chip of all combinations, and is thought to be the most efficient way of milling metal when power is the chief consideration. It is shown that the average thickness of chip when both feed and depth of cut are varied is not a satisfactory basis for an energy equation. (Paper No. RP-54-4, by O. W. Boston and Charles E. Kraus.)

Flow of Steam Through Square-Edged Orifices in a 4-In. Line

THE flow of steam through square-edged orifices has little in the way of available data. Tests were therefore run to secure the necessary data on steam-flow measurement. The objects were to determine coefficients for steam flow through square-edged orifices under conditions favorable to securing basic coefficients; to determine effects of various types of disturbances, both upstream and downstream, on basic coefficients; to determine effects of straightening vanes located 0.5 pipe diameter from the upstream edge of the orifice plate on coefficients. The general statement of the results may be made that, for the disturbances covered in the report, and with the orifices installed with vanes $^1/_2$ D from the upstream edge of the orifice plate, the actual coefficients will be near to 1 per cent of the 0.99 standard coefficient, for d/D ratios not over 0.75. (Paper No. RP-54-6, by W. W. Frymoyer and A. Herschel.)

Optimum Conditions in Journal Bearings

THIS paper presents in practical, serviceable form the most important results obtainable from the hydrodynamic theory of the oil film. The general theoretical treatment is supplemented by numerical evaluations whereby the conditions for the maximum load and for the minimum friction are determined for the ideal bearing; and these results are reduced to apply to practical cases by means of approximate methods. Tables and graphs are given, by means of which the loads, the losses by friction, and other characteristics of specified bearing forms may be determined, and special consideration is given to the optimum conditions for more or less arbitrary bearing proportions. (Paper No. RP-54-7, by Albert Kingsbury.)

Fluxing of Ashes and Slags as Related to the Slagging-Type Furnace

THIS paper is presented as a report for the Special Research Committee on the Removal of Ash as Molten Slag from Powdered-Coal Furnaces. The primary object of the investigation was to obtain data on the fluxing of coal-ash slags to enable users of slagging-type boilers to increase the fluidity of the deposited ash should it not be possible to tap at available furnace temperatures. Studies were made using a platinum-wound furnace, supplemented by a gas furnace with a 32-in. by 28-in. hearth. A standard of fluidity desirable for easy tapping was established, and the results were expressed as the temperature necessary to produce this fluidity, designated the flow temperature. Values for flow temperature in terms of the chemical composition of the ash, or ash plus flux, were determined for a range of ashes found in American coals, and for additions of the following fluxes: iron ore, limestone, dolomite, fluorspar, saltcake, steel slags, and some less important minerals. It is deduced that limestone or dolomite would be the most economical material to use for slagging-type boilers as now built, and from a diagram the quantity of flux can be computed. The investigation was carried beyond

present requirements for slagging-type boilers, and to flow temperatures below 2400 F. A complete diagram is given for coal-ash-lime-iron showing the flow temperature plotted against composition. (Paper No. RP-54-9, by P. Nicholls and W. T. Reid.)

Pressure Distribution in Oil Films of Journal Bearings

ONE fact which is becoming widely recognized by users of journal bearings is that under proper conditions of operation the load applied to a journal bearing is supported by the hydrostatic pressures built up in a film of lubricant wedged between and completely separating the journal and bearing. This paper describes an investigation at the Bureau of Standards the purpose of which was to determine the distribution of pressure in the oil film of a full journal bearing for various conditions of operation and of bearing construction. A specially designed apparatus provided a means for measuring the film pressures at practically all points on the surface of a bearing when operating under different conditions of load, speed, and viscosity of the lubricant. The results of nine tests made under conditions involving changes in clearance, load, speed, and viscosity are presented graphically in the form of pressure-distribution curves. In conclusion the characteristics of the film-pressure distribution are summarized, and further steps toward a better understanding of the pressure distribution are outlined. (Paper No. RP-54-8, by S. A. McKee and T. R. McKee.)

The SO_3-CO_4 Ratio for the Prevention of Sulphate Boiler Scale

THE investigation described in this paper is a logical development of R. E. Hall's well-known work. The authors felt that the true value of the SO_4-CO_3 ratio must be appreciably greater than the value calculated by Hall, and, as a result, a program of research at the University of Michigan was sponsored by The Detroit Edison Company to determine more accurately, if possible, the solubility relations of boiler waters. The work done on this project is described by the authors. (Paper No. RP-54-10, by Everett P. Partridge, W. C. Schroeder, and R. C. Adams, Jr.)

Design and Investigation of a Spring in Which All Coils Nest Simultaneously

THE purpose of this study was to design a spring of constant slope, the lower coils of which would not nest until loads larger than those causing corresponding coils to nest in constant-pitch springs were placed on the spring. The results obtained when the spring of constant slope was compared with one of constant pitch made it seem desirable to try to design a spring in which all coils would nest simultaneously. Work with this spring and with those previously investigated leads to the conviction that end effects considerably influence the amount of deflection. This spring, having a complete dead coil at each end, must be somewhat affected by this influence, though no experiments have been made to determine how much. The result of this influence would be that the experimental deflections would be greater than the theoretical, which agrees with the results found. (Paper No. RP-54-11, by J. B. Reynolds and O. B. Schier.)

Design and Investigation of Conical Springs With Coils of a Constant Slope

THE development of design and the investigation of the characteristics of conical springs with coils of constant slope rather than constant pitch are presented, and the paper also compares the actual performance of these springs with those of constant pitch as well as with the theoretical performance. The conclusions drawn from the investigation are: It is possible with existing formulas to predict the behavior of conical springs. For chrome-vanadium steel of the analysis given, the best heat treatment is to normalize at 1600 F, cool in air, quench at 1550 F in oil, and temper at 900 F in air. Conical springs of constant slope behave more like helical springs than do conical springs of constant pitch as regards load-deflection characteristics. (Paper No. RP-54-12, by J. B. Reynolds and O. B. Schier.)

Determination of Carbonate, Hydroxide, and Phosphate in Boiler Waters

IN THIS progress report of Subcommittee No. 8 of the Joint Research Committee on Boiler-Feedwater Studies, it is stated that the work of the subcommittee this year has involved critical examination of the methods generally used for examining boiler water, with a view of establishing methods for plant control and referee work that later might be recommended for adoption as standard in the industry. There has been much dissatisfaction with several methods for determining certain constituents in boiler water. This is because the methods used were developed for examining other types of water and consequently are not always applicable for accurate testing of water in steam boilers.

Those methods which, in the opinion of the subcommittee, required immediate consideration because they had to do with the determination of constituents important in control work in most plants, and because no generally accepted scheme of procedure had been found to yield satisfactory results, were: (1) Methods for the determination of alkalinity, especially that due to carbonate salts; (2) those for dissolved oxygen and carbon dioxide; and (3) those for the determination of phosphates and silicates, inasmuch as these salts influence alkalinity and, in some cases, interfere with its determinations.

It was felt that the most logical way to clear up the questions arising in connection with these methods was to put the matter before a competent technician who would devote his entire time to the problem. The subcommittee was authorized to establish a fellowship in some university to carry out the work, and one was established at the University of Michigan. The first problem taken up was methods for determining alkalinities and some of those ions influencing alkalinity and its determination. The report tells of the progress made in carrying out this work. (Paper No. RP-54-13, by W. C. Schroeder and C. H. Fellows.)

Tungsten-Carbide and Other Hard Cutting Materials

THIS progress report No. 3 of the Subcommittee on Metal-Cutting Materials of the A.S.M.E. Special Research Committee on the Cutting of Metals, gives the text of a questionnaire on the use of new cutting alloys that was sent to the leading manufacturing establishments of the country, and an analysis of the replies received thereto. This analysis covers information on the extent of application of the new alloys in tools; types of operations successfully performed; types of material successfully machined with alloy tools; grinding, lapping, and honing of hard-cutting-material tools; handling chips; finishes; etc. Data are given showing savings in money, hours or percentages on typical successful operations performed on engine, turret, and automatic lathes, vertical and horizontal boring mills, milling machines, and drill presses. Further information yielded by the replies to the questionnaire deals with angles of tool clearance and rake, and on methods of mounting tools. (Paper No. RP-54-14, by Coleman Sellers.)

A.S.M.E. Boiler Code

Interpretations

THE Boiler Code Committee meets monthly for the purpose of considering communications relative to the Boiler Code. Any one desiring information as to the application of the Code is requested to communicate with the Secretary of the Committee, 29 West 39th St., New York, N. Y.

The procedure of the Committee in handling the cases is as follows: All inquiries must be in written form before they are accepted for consideration. Copies are sent by the Secretary of the Committee to all of the members of the Committee. The interpretation, in the form of a reply, is then prepared by the Committee and passed upon at a regular meeting of the Committee. This interpretation is later submitted to the Council of The American Society of Mechanical Engineers for approval, after which it is issued to the inquirer and published in MECHANICAL ENGINEERING.

Below are given records of the interpretation of the Committee in Cases Nos. 732 to 736, inclusive, as formulated at the meeting of October 28, 1932, all having been approved by the Council. In accordance with established practice, names of inquirers have been omitted.

CASE No. 732

Inquiry: May open-hearth-process steel having a tensile strength of from 55,000 to 65,000 lb per sq in., which meets A.S.T.M. Specifications A7-29 for Structural Steel for Bridges, be used for Class 3 fusion-welded unfired pressure vessels having a shell thickness of less than $^1/_4$ in., provided it is of good weldable quality, the working stress does not exceed 5600 lb per sq in., and all other Code requirements are met?

Reply: In view of the data submitted regarding the successful use of this material over a long period of time under the conditions specified in the inquiry, it is the opinion of the Boiler Code Committee that with the restrictions as stated, safe construction will result from the use of this material.

CASE No. 733 (In the hands of the Committee)

CASE No. 734 (In the hands of the Committee)

CASE No. 735

Inquiry: Is it permissible to form a manhole opening by insertion of a structural-steel ring in the opening in a shell or head and welding it thereto, provided the ring is so proportioned as to adequately reinforce the opening under revised Par. U-59 of the Code?

Reply: Rules are given in Par. U-59 for the proper reinforcement of openings cut in shells or heads, and it is the opinion of the Boiler Code Committee that if manhole openings are fitted with welded reinforcing rings of the type referred to, which are proportioned according to the requirements of Par. U-59, the construction will not conflict with the requirements of the Code.

CASE No. 736

Inquiry: Was it the intention of the Boiler Code Committee to eliminate the former provision in Par. P-186 of the Code for the use of fusion welding on pressure parts of boilers where the stress is carried by other construction and the safety of the structure is not dependent upon the weld? This clause was replaced in the latest Edition of the Code by a stipulation that "fusion welding may be used in boilers as specified in this section of the Code." Examples of the construction details in question are the welding together of abutting plate edges under the butt straps of riveted joints and the cutting away of one edge of a lapped joint where the end of the shell meets a circumferential joint or a head.

Reply: It was not the intent of the Committee to eliminate the provision in the Code for the use of fusion welding on pressure parts of boilers where the stress is carried by other construction and the safety of the structure is not dependent upon the weld. The provisions of the third section of Par. P-186 are based upon the above-mentioned former rule. Construction details of the type described in the inquiry are therefore permissible (see also Case No. 350).

Revisions and Addenda to the Boiler Construction Code

IT IS THE policy of the Boiler Code Committee to receive and consider as promptly as possible any desired revision of the Rules and its Codes. Any suggestions for revisions or modifications that are approved by the Committee will be recommended for addenda to the Code, to be included later in the proper place in the Code.

The following proposed revisions have been approved for publication as addenda to the Code. They are published below with the corresponding paragraph numbers to identify their locations in the various sections of the Code, and are submitted for criticisms and approval from any one interested therein. Added words are printed in SMALL CAPITALS; deleted words are enclosed in brackets [ ]. Communications should be addressed to the Secretary of the Boiler Code Committee, 29 West 39th St., New York, N. Y., in order that they may be presented to the Committee for consideration.

PARS. P-108 AND U-76. REVISE THE THIRD SENTENCE OF THE FIRST SECTION OF PAR. P-108, AND THE THIRD SENTENCE OF THE THIRD SECTION OF PAR. U-76 TO READ:

The structure or parts of the structure shall be brought slowly up to the specified temperature and held at that temperature for a period of TIME PROPORTIONED ON THE BASIS OF at least one hour per inch of thickness, and shall be allowed to cool slowly in a still atmosphere.

PAR. P-314. ADD THE FOLLOWING SENTENCE:

IF NECESSARY, THE DISCHARGE END OF A FEED PIPE SHALL BE FITTED WITH A BAFFLE TO DIVERT THE FLOW FROM THE RIVETED JOINT.

PAR. P-327. REVISE SECOND SENTENCE TO READ:

The minimum size of firedoor opening in an internally fired boiler in which the minimum furnace dimension is 24 in. or over, shall be not less than 11 [in. high and not less than] BY 15 in. [wide], OR 10 BY 16 IN. IN SIZE. A CIRCULAR OPENING SHALL BE NOT LESS THAN 15 IN. IN DIAMETER.

PAR. P-328. REVISED:

P-328. A water-tube boiler shall have the firing doors of the inward-opening type, unless such doors are provided with substantial and effective latching or fastening devices or otherwise so constructed as to prevent them, when closed, from being blown open by pressure on the furnace side.

These latches or fastenings shall be of the [automatic] positive SELF-locking type [having a latch or bolt in a fixed bracket on the door, door frame or furnace front. The latch or bolt shall be dependent upon gravity or counterweighted]. Fric-

tion contacts, latches, or bolts actuated by springs shall not be used. The foregoing requirements for latches or fastenings shall not apply to coal openings of down-draft or similar furnaces.

All other doors, except explosion doors, not used in the firing of the boiler, may be provided with bolts or fastenings in lieu of SELF-LOCKING [automatic] latching devices.

Explosion doors IF USED AND [necessarily provided to relieve furnace pressure,] if located in the setting walls, within 7 ft of the firing floor or operating platform, shall be provided with substantial deflectors to divert the blast.

MATERIAL SPECIFICATIONS SECTION: REVISIONS HAVE BEEN PROPOSED IN THE FOLLOWING SPECIFICATIONS:

Spec. S-1 —Par. 2
Spec. S-5 —Par. 1
Spec. S-6 —Par. 3
Spec. S-7 —Par. 1
Spec. S-17—Pars. 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 12, 14, 15, 16, 17
Spec. S-18—Pars. 2, 3, 5

Those desiring a complete set of these revisions, may obtain it by addressing the Secretary of the Boiler Code Committee.

PARS. H-42 AND H-95 REVISED:

H-42 and H-95. *Connections for Safety [and Water Relief] Valves.* [Every boiler shall have proper outlet connections for the required safety or water relief valves, independent of any other connection outside of the boiler. A steam equalizing pipe between boilers is not to be considered as a connection outside of the boilers in applying the requirements of this paragraph.] The area of the opening [is to] SHALL be at least equal to the aggregate area based on the nominal diameters of all of the safety valves with which it connects. A screwed connection may be used for attaching a safety valve.

PARS. H-46 AND H-99 REVISED:

H-46 and H-99. Safety valves shall be connected to [the] boilers WITH SPINDLE VERTICAL IF POSSIBLE, DIRECTLY TO A TAPPING IN [independent of other connections and be attached directly or as close as possible to] the boiler, OR BY TWO CLOSE NIPPLES AND A TEE FOR A SURFACE BLOW CONNECTION OR FOR A WATER-COLUMN TOP CONNECTION, [without any unnecessary intervening pipe or fitting except the] OR TO A Y-base [forming a part of the] twin valve CONNECTION, OR TO A VALVELESS STEAM EQUALIZING PIPE BETWEEN ADJACENT BOILERS, OR TO A VALVELESS HEADER CONNECTING STEAM OUTLETS ON THE SAME BOILER [or a steam equalizing pipe between boilers. A safety valve or water relief valve shall not be connected to an internal pipe in the boiler. Safety valves or water relief valves shall be connected so as to stand upright with the spindle vertical when possible].

Economic Effects of Urbanization

(*Continued from page 31*)

another type of security that is possible up to any reasonable necessity. That is straight insurance, by which is meant the type of insurance that is continuously liquidated and does not depend upon an invested fund. Undoubtedly there are other possible types of security, provided men will make some effort to understand and control them. The most serious part of the problem is how to make the city man satisfied with mere reality. We are creatures of the soil, and when we are close to our natural habitat we have that ideal sense of security that all creatures have in their proper environment. There is something that we miss in cities that we strive always to obtain. The thought that we wish to express is difficult. It is something of what Samuel Johnson expressed at the sale of his father-in-law's brewery. He said, "We are not here to sell a parcel of boilers and vats, but the potentiality of growing rich beyond the dreams of avarice." The Kreugers and Insulls knew us and sold us the same idea; not mere material, not mere satisfaction for avarice, but something beyond the *dreams* of avarice; an ideal something that is romance, something compounded of what the English gentleman thought of as comfort and what the mystic of the middle ages thought of as salvation.

The crust of this planet has done very well by the human race. It can do still better. It, with our industrial system, can provide houses that a little while ago would have delighted kings; with goods that Nebuchadrezzar at his feasts could not have imagined. For the romantic it can even provide means to fly, and for the practical it can provide all the gadgets that any human heart could desire. It can provide all of these things in great abundance and to all of us. But it cannot now provide, nor in the nature of things can it ever provide, any such mystic and fantastic financial security as we dreamed of in the years before 1929.

The Engineer in Public Life

(*Continued from page 9*)

If the engineer is to be granted exclusive privileges in his own narrow professional field, he must make himself not only master of this narrow field, but also of its ramifications as it affects public welfare. In the past he has proceeded blindly to develop a technique of production, which, while supplying the necessities of life in abundance, has created economic and social problems that stagger the mind of our best economists. It is high time that he himself tried to understand what he is doing, and if possible offered remedies for the economic troubles he has caused; and this will undoubtedly take him far afield in his studies along the lines indicated in the foregoing. Licensing, I believe, can be defended only upon such grounds. As a gild or a trade-union measure it is indefensible. It will be interesting indeed to see what the engineer will do with such a great opportunity.

Machinery Industry and the Business Cycle

(*Continued from page 12*)

in an educational way, as is now being done by Mr. Robertson's committee, to bring home to industry in general a realization of the consequences that result from the absence of an equipment policy, we should nevertheless at the same time take steps to protect our businesses and personal interests in the future from disastrous consequences such as those that have flowed from the situation as it has existed heretofore.

CORRESPONDENCE

READERS are asked to make the fullest use of this department of "Mechanical Engineering." Contributions particularly welcomed at all times are discussions of papers published in this journal, brief articles of current interest to mechanical engineers, or comments from members of The American Society of Mechanical Engineers on its activities or policies in Research and Standardization.

Cutting Overhead at Reduced Outputs

To the Editor:

The important subject treated by Mr. Flanders in Mechanical Engineering for September (the economics of machine production) may be considered in some detail by further analyzing the overhead expenses.

The total cost of production may consist of: (1) direct expenses, taken to be proportional to the volume of output (material and direct wages), and (2) the overhead. The latter need not be constant for varying outputs, as was assumed in Mr. Flanders' graphs, but may be reduced for small outputs. It will be shown that it is of paramount importance in modern industry to cut the total overhead expense in times of depression. In order to simplify the mathematical treatment we divide the overhead into a constant part and a part assumed

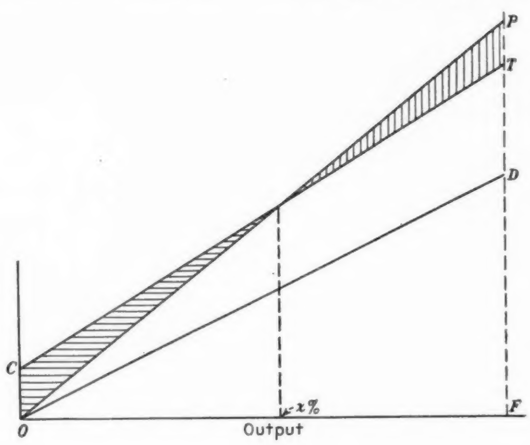


FIG. 1

to be proportional to output. This leads to Fig. 1 for the total cost of production.

On the basis of full capacity the total overhead *DT* is taken as t per cent of the direct expenses *FD*, and the profit *TP* included in selling prices may then be w per cent of the total cost of production *FT*. The constant part of the overhead *OC* is assumed to be c per cent of the total overhead *DT* at full output. It is easily seen that the output at which profit disappears and loss begins (x per cent of full capacity), is determined from the relation

$$x = \frac{100}{1 + \frac{w}{c} + \frac{100\,w}{ct}} \quad \text{(See note appended)} \ldots\ldots [1]$$

and for profits of 5, 10, 15, and 20 per cent the curves in Fig. 2 are found.

The critical output x depends upon the nature of the industry (highly mechanized means a high value of t) but mainly on the value of c. Cutting overhead at reduced outputs (low value of c) is absolutely necessary. In most industries the largest item in the overhead is that for wages of foremen, inspectors, office workers, etc., and a reduction of any importance in overhead will necessitate a temporary sacrifice of

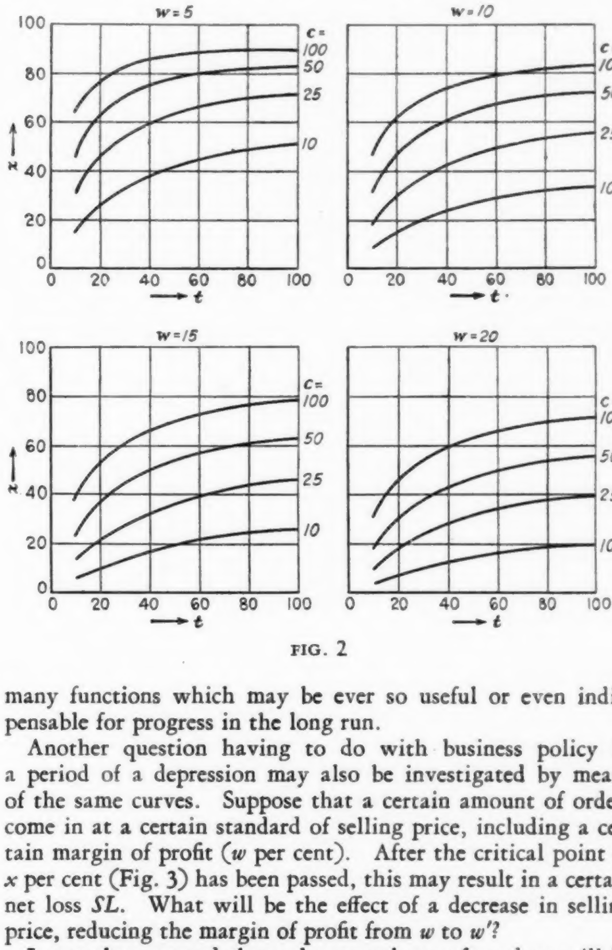


FIG. 2

many functions which may be ever so useful or even indispensable for progress in the long run.

Another question having to do with business policy in a period of a depression may also be investigated by means of the same curves. Suppose that a certain amount of orders come in at a certain standard of selling price, including a certain margin of profit (w per cent). After the critical point of x per cent (Fig. 3) has been passed, this may result in a certain net loss *SL*. What will be the effect of a decrease in selling price, reducing the margin of profit from w to w'?

It may be expected that a larger volume of product will be sold at the lower price. Will now this larger output compensate for the lower price? This will obviously be the case when

$$\frac{x'}{x} = \frac{ct + 100w + wt}{ct + 100w' + w't} \ldots\ldots\ldots\ldots [2]$$

Fig. 4 presents graphical solutions of this equation for a few values of t and for $w = 10$. It will be seen that even a slight reduction in selling price would only be compensated

for if a fairly considerable increase in output might be expected, especially so if it were possible to cut overhead at low outputs (i.e., a low c value).

Apart from other dangers of the price-cutting policy, on which the writer will not dwell, one would do well to examine every possibility of reducing the constant part of the overhead

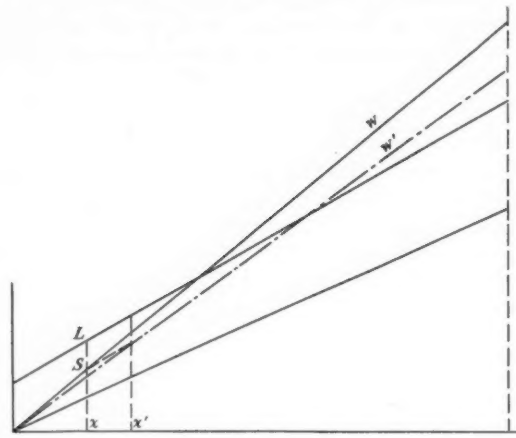


FIG. 3

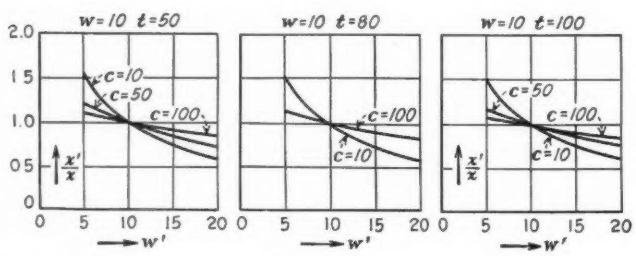


FIG. 4

(maybe temporarily) before deciding to "force his hand" by a lower price.

Fig. 5 is submitted by way of illustration. Of the indirect expenses shown, almost every item may be slightly reduced, once the output has gone down below a certain percentage. Depending upon the nature of the industry and the item involved, these points of stepping down will have different locations. An exception, however, is made for "waiting time." Whenever a workman cannot be given a new job at the moment he finishes the one on which he is at work, he is entitled to a waiting ticket. At higher outputs such a circumstance should be practically impossible; at low outputs it cannot be avoided, especially since orders for odd work will be accepted by the concern in addition to standard work, and such odd jobs require that a certain reserve in employees be available. So this item of overhead will increase at lower outputs. For obvious reasons a similar increase of expenses at lower outputs may be expected for advertising, etc.

Depreciation may be reduced at low outputs, since the useful life of machines and equipment may be lengthened by less intense use. This policy may not be justified in cases where the useful life is limited by obsolescence only.

The sum total of indirect expenses gives the stepped line for total cost of production, which line is replaced by a straight line for use in mathematical treatment.

D. DRESDEN.[1]

Utrecht, Holland.

[1] Prof. Ir. D. Dresden, President, Jaffa Engineering Works.

NOTE: Referring to Fig. 1, Equation [1] is derived as follows:

$$\text{Revenue} = \text{Direct exp.} + \text{const. overhead} + \text{variable overhead}$$

$$FD\left(1+\frac{t}{100}\right)\left(1+\frac{w}{100}\right)\frac{x}{100} = FD\frac{x}{100} + FD\frac{t}{100}\frac{c}{100} + FD\frac{t}{100}\left(1-\frac{c}{100}\right)\frac{x}{100}$$

$$\frac{x(w+t)}{100}+\frac{xwt}{10{,}000}=\frac{tc}{100}+\frac{tx}{100}-\frac{tcx}{10{,}000}$$

$$x=\frac{tc}{w+\frac{wt}{100}+\frac{tc}{100}}=\frac{100}{\frac{100\,w}{ct}+\frac{w}{c}+1}$$

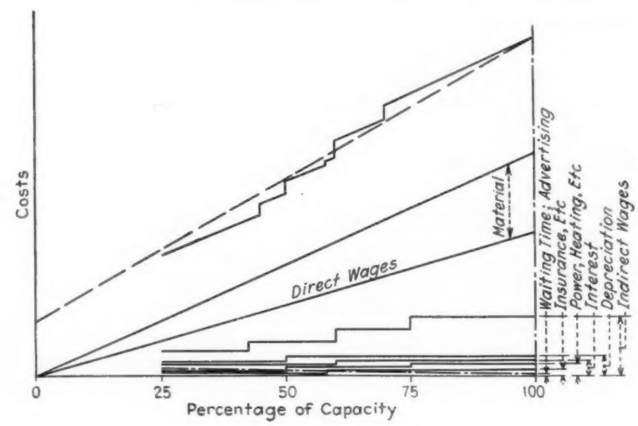


FIG. 5

Equation [2] is obtained by making the revenue—direct expense—constant overhead—variable overhead equal for both x and x'.

$$\frac{x}{100}\left(1+\frac{t}{100}\right)\left(1+\frac{w}{100}\right)-\frac{x}{100}-\text{const}-\frac{x}{100}\left(1-\frac{c}{100}\right)\frac{t}{100}$$
$$=\frac{x'}{100}\left(1+\frac{t}{100}\right)\left(1+\frac{w'}{100}\right)-\frac{x'}{100}-\text{const}$$
$$-\frac{x'}{100}\left(1-\frac{c}{100}\right)\frac{t}{100}$$

$$x+\frac{x(w+t)}{100}+\frac{xwt}{10{,}000}-x-\frac{xt}{100}+\frac{xct}{10{,}000}$$
$$=x'+\frac{x'(w'+t)}{100}+\frac{x'w't}{10{,}000}-x'-\frac{x't}{100}+\frac{x'ct}{10{,}000}$$

$$100xw+xwt+xct=100x'w'+x'w't+x'ct$$

$$\frac{x'}{x}=\frac{ct+100w+wt}{ct+100w'+w't}$$

A Scheme for Adjusting Wage Rates

TO THE EDITOR:

A new formula for wage payment is here proposed which, it is believed, follows the natural course of wages under balanced economic conditions, and which, therefore, if applied in ad-

vance, would tend to avert unbalanced conditions or at least damp their violence.

The formula is as follows:

> The new wage is to the base as the new product per dollar of production cost is to the base.

Expressed mathematically,

$$\frac{W_2}{W_1} = \frac{P_2/(W_2 + O_2)}{P_1/(W_1 + O_1)}$$

in which W_1 and O_1 are the indices of wages and overhead for any condition taken as base, and P_1 is the index of production for the same condition. W_2, O_2, and P_2 have similar meanings under the new condition for which wages are being calculated. W_2 is the only unknown quantity.

Index numbers are used instead of dollars and cents in order to lessen the amount of calculation required. When the new index is found, it is used as a multiplier for any individual wage. By "production" is meant not only production in the technical sense, but any activity for which wages or commissions are paid, since the formula is of universal application. By "overhead" is meant all costs other than labor stated in terms of labor.

TABLE 1 SHOWING INCREASE OF WAGES WITH PRODUCTION

Decrease in overhead, per cent	Increase in production, per cent: 0	20	40	60	80	100
	Increase in wages, per cent					
INDUSTRY No. 1—BASE OVERHEAD 50 PER CENT						
0	0	7.5	14.0	20.0	25.4	30.3
10	2.0	10.0	17.0	23.0	28.5	34.0
20	4.0	12.3	19.5	26.0	32.0	38.0
30	6.0	15.0	22.5	29.6	36.0	41.7
40	8.0	17.5	25.5	33.0	39.5	45.5
50	10.5	20.0	28.5	35.9	43.5	50.0
INDUSTRY No. 2—BASE OVERHEAD 500 PER CENT						
0	0	2.5	4.4	5.9	7.2	8.3
10	7.6	10.6	13.0	15.0	16.7	17.9
20	16.2	20.0	23.0	25.4	27.4	29.1
30	26.0	30.7	34.5	37.6	40.2	42.4
40	37.2	43.1	47.9	51.9	55.4	58.3
50	50.0	57.4	63.6	68.8	73.3	77.2

Table 1 illustrates the application of this formula to two hypothetical industries or departments, one with low overhead and the other with very high overhead. Any number of such tables and graphs can be made, not only for conditions of increasing production and falling overhead, but also for decreasing production and rising overhead, the latter showing at what rate wages should be cut in order to preserve balanced conditions.

A study of the tables and graphs made from them shows the following novel and outstanding features:

1 The wage curve for each industry or department having different relative costs is suited to keep equilibrium in that particular industry continuously. All previously suggested systems of piece work, premium or bonus, whatever the name, touch the equilibrium curve at one point only and contain no general law for guiding from point to point.

2 A study of numerous settlements after long-drawn-out industrial disputes in which it is presumed the parties were of equal strength, discloses that the settlements follow this group of curves with remarkable closeness. This is therefore a method of gaining the same result by reason as by warfare, and at less expense.

3 The more highly mechanized the industry, the more will the worker gain from improved equipment and saving of waste.

4 If the decrease of prices is made to parallel the decrease of costs resulting from the use of this formula, then the worker's purchasing power will keep exact pace with production. Prices, however, can be somewhat higher than that and still be in equilibrium, to the extent that purchasing power comes from other than the employed groups.

WM. F. TURNBULL.[2]

New York, N. Y.

Roads and the Transportation Industry

TO THE EDITOR:

Referring to the article by Leon Cammen[3] in the August number of MECHANICAL ENGINEERING, and to the comments thereon in the October issue, I believe that one point is not considered sufficiently in these discussions of the transportation industry.

In these days when taxpayers' alliances and other organizations are pressing local and state governments for reductions of taxes or expenditures, it may not be amiss to divert attention to the improvements and maintenance of roads which consume a large percentage of today's taxes. We have splendid concrete roads, and want more of them. They make comfortable travel and trucking possible. The road bed is a mechanical construction just as are bridges and machines, and an adequate factor of safety must be allowed for the loads carried by it. This is especially true in climates where freezing will materially reduce the strength of the pavement.

When a truck driver boasts of a 16-ton pay load on his trailer, which would give a wheel load of approximately 12,000 lb, then the Highway Department should think of the foundations on which such a load travels. A heavily loaded vehicle does more damage than all the light vehicles combined, and the heavy loads necessitate stronger construction of roads and bridges, wider roads, and more repair and maintenance, all of which increase the cost of improvements and public investment. The heavy vehicles do not pay their portion of taxes, thereby shifting the cost of transportation slowly and silently to the taxpayers. We engineers rejoice in the record truck capacities and weights carried by our transportation industries, but in regard to trucking the taxpayers are now providing the greatest subsidy ever given to any industry, or silently taken by it because the good roads invite records to be made.

In analyzing the tax levied on heavy trucks we find that these pay hardly 10 per cent of what they justly should for wheel loads over 4000 lb. To provide an adequate safety factor for the load, 6000 to 8000 lb should be the maximum wheel load permitted. The tax should increase at least as the third power of the increase in wheel load. Cities, counties, and states must come to the proper ratio in the near future in order to reduce the expenditures on roads out of tax funds. The problems are similar all over the country, and uniform state laws would be desirable for the trucking business.

Super-highways will not help the taxpayer even if those for trucks are private toll roads. For house-to-house delivery it will be necessary for heavy vehicles to travel over lighter road beds, not built for such loads. If heavy trucking should be limited to the super-highways, with distributing centers to lighter roads, as is the practice of railroads, then they would be of no benefit to the trucking business. The railroads are built for this purpose and are paying taxes on their investment. With good-will it should be possible to coordinate railroad,

[2] Equipment Engineer, Third Avenue Railway System. Mem. A.S.M.E.

[3] "The Transportation Dilemma," MECHANICAL ENGINEERING, August, 1932, p. 533.

trucking, and highway transportation without shifting the cost of that industry almost entirely on to the taxpayers.

W. LEHMAN.[4]

South Milwaukee, Wis.

Eight as a Basis for Our System of Numbers

TO THE EDITOR:

I am in substantial agreement with Mr. Tingley's letter on this subject, published on page 663 of the September issue of MECHANICAL ENGINEERING, but desire to state for his information that I published an article entitled "The Octimal System of Numerals" as late as 1920 (March 23) in the *American Machinist*. I am unfamiliar with the 1887 publication which Mr. Tingley declares is the latest on the subject, and should greatly appreciate learning where it appeared.

Does Mr. Tingley really think there is a possibility of converting the world to this system of numbers? It does seem that our present system is too deeply ingrained; on the other hand, mankind will be using arithmetic a long time, as he points out.

Since Mr. Tingley agrees that our number system is incompatible with our mental system, does not the remedy lie in changing our number system? Merely doubling or halving and quartering our present units to obtain different magnitudes, without fundamentally changing our number system, will gain us little. We are doing that now wherever it is possible or useful. My basic objection to the metric system is that it fits our number system but not our mental system. Change our number system, and every one will want some sort of a new Octimal Metric System.

FREDERICK FRANZ.[5]

New Haven, Conn.

The Product of the Engineering Colleges

TO THE EDITOR:

In his article "The Product of the Engineering Colleges," in the October issue of MECHANICAL ENGINEERING, President Prentice of Rose has performed quite an interesting service in analyzing the distribution of those who attained the distinction of being listed in the 3rd Edition of "Who's Who in Engineering."

President Prentice is justified in his assumption concerning the care taken by the publishers of "Who's Who in Engineering," in the endeavor to secure all eligible engineers, and only those who were eligible. I know of their diligence and efficiency, because I served as secretary for the A.E.C. Committee which set up the standards for inclusion.

His Table 1 is most enlightening. Table 2, however, gives an unusual advantage to the purely technical school. Take, for example, the University of Florida, which is a young institution, established in 1905. The engineering enrolment at present constitutes 14 per cent of the entire student body. The institution has given B.S. degrees in engineering to 385 men, and apparently 10 of these are listed in "Who's Who in Engineering." On this basis the University of Florida would rank well up in Table 2, with 2.59 per cent of its total graduates in engineering in "Who's Who in Engineering." The same thing is true of the University of California. If only the graduates of its engineering colleges were taken into consideration, I believe that the rank of the latter institution would be very close to, if not at, the top of Table 2.

B. R. VAN LEER.[6]

Gainesville, Fla.

TO THE EDITOR:

In Table 2 of the article by D. B. Prentice on "The Product of the Engineering Colleges" that appeared in the October issue of MECHANICAL ENGINEERING, I notice that the total number of graduates from the Virginia Polytechnic Institute, regardless of curricula, has been used. I judge from this that it was assumed that the Virginia Polytechnic Institute was entirely engineering. V.P.I. is the land-grant college of Virginia, comparable with Purdue University, while other schools in this list are more strictly engineering in character. Since only the engineering graduates from Purdue University have been used, it would be more proper to use only engineering graduates from V.P.I. The total number for engineering, including agricultural engineering and commercial engineering, which are administered in other schools than the School of Engineering, is 1897. This change would bring the percentage for V.P.I. to 1.95 and raise our position in this table to eleventh place, between Rensselaer and California Institute of Technology.

I realize the difficulty as mentioned in the article of taking into consideration a more rapid growth in recent years of some institutions as compared with those which have not experienced such growth. I believe I am correct in stating that the first three or four schools in Table 2 are schools which have not experienced such growth, and it appears, therefore, that this question is one of major importance in interpreting the table.

Since one of the qualifications for admission to "Who's Who in Engineering" is at least ten years of active practice, would it not be possible to eliminate to some extent this consideration by comparing the numbers of alumni who were graduated prior to 1922?

E. B. NORRIS.[7]

Blacksburg, Va.

TO THE EDITOR:

I was very much interested in Dean Norris' letter. I had made the mistake of thinking that Virginia Polytechnic Institute, as its name implies, was almost wholly engineering. Had the volume sent out by the American Council on Education classified its graduates, I could have made the same distinction that was possible for Purdue. Dean Norris probably noticed in the text of the article in MECHANICAL ENGINEERING that I cautioned readers against placing too much weight on the figures in Table 2.

In regard to the question of the growth of the first three or four schools in Table 2, I have compared the registrations as given in the 1932 "World Almanac" with those given in the issue for 1923. I find that Michigan School of Mines increased from 331 to 570, or 72 per cent; Rose Polytechnic Institute from 238 to 332, or 40 per cent; Colorado School of Mines from 478 to 544, or 14 per cent; Worcester Polytechnic Institute from 502 to 663, or 32 per cent; Purdue from 3110 to 4962, or 60 per cent; and Virginia Polytechnic Institute from

[4] Chief Engineer, Bucyrus-Erie Co. Mem. A.S.M.E.

[5] Engineer. Mem. A.S.M.E.

[6] Dean of Engineering, University of Florida. Mem. A.S.M.E.

[7] Dean of Engineering, Virginia Polytechnic Institute. Mem. A.S.M.E.

975 to 1617, or 66 per cent. These increases vary considerably, but the largest percentage growth of the colleges mentioned is that of the school which stands first in Table 2.

D. B. PRENTICE.[8]

Terre Haute, Ind.

Public Works and Recovery

TO THE EDITOR:

There has been much discussion lately in literature and otherwise about the effect of public works upon recovery. (See, among other articles, MECHANICAL ENGINEERING, September, p. 623, and November, p. 753.)

There is one aspect, however, that is generally overlooked, and yet it is not unimportant. It concerns itself with the extent to which a public-works program alleviates unemployment conditions. In other words, it assumes the yardstick to be the actual number of men that are called back to work through such a program, and the wages paid to them.

The accompanying table furnishes some information on these matters. It gives particulars regarding 8 public works involving a total expenditure of $432,000 that have come to the author's attention. Most of these were financed through public bond issues. The list includes water reservoirs, water conduits, storm sewers, and overhead crossings.

EMPLOYMENT PERCENTAGES ON PUBLIC WORKS

Project	Portion of bid paid for wages, per cent (approx.)	Number of men employed compared with number of unemployed, per cent (max.)
A	20	0.20
B	20	0.40
C	17	0.40
D	18	0.20
E	24	0.25
F	20	0.50
G	26	0.80
H	19	0.10
Average	21	

Total cost of the 8 projects = $432,000; total approximate man-hours = 184,700, varying from 3500 in the smallest to 61,000 in the largest project.

In deriving the final figures given, the approximate number of man-hours was first determined by an actual count of men employed, except in some instances where this information had to be estimated in part. This count included all men employed on the project, such as truck drivers hauling material, common labor, machine operators, and all of the contractor's key men employed on the particular job. In two cases the bids also covered the manufacture of concrete pipe, and the men employed in making the pipe are included.

An arbitrary wage scale of 50 cents an hour was assumed. The second column in the table shows the percentage of the bid price that was paid for wages. As all men that were employed were included and a high wage has been assumed, the resulting percentages are, if anything, too high. It must be remembered that, if correct salaries were used for key men, the result would perhaps be different. But many of the key men are carried by the contractor in any case, and while such projects of course benefit them, they do not usually mean the difference between employment and non-employment.

The last column shows in percentage the maximum number of men employed at any one time compared with the estimated number of unemployed in the same district.

The number of men employed and the wages paid are small compared with the expense involved. As the money comes from taxation, i.e., from a large number of small contributors, such work has the tendency to still further concentrate wealth and help unbalance conditions. The writer believes that the flywheel effect of public works has been greatly overestimated. To be effective in this way the public-works system will have to be tremendously enlarged or legislation invoked to bring about more hand labor. Perhaps both procedures are possible.

Public projects at present under way offer excellent opportunities for the collection of valuable data on this problem. The collection and analysis of such information should be encouraged and, if possible, sponsored by some society committee. After sufficient facts become available, the subject can be discussed intelligently.

Under present conditions, however, the writer believes that many changes must take place before unemployment benefits from public works will measure up to expectations.

J. BILLETER.[9]

Salt Lake City, Utah.

Nitrogen in Arc Welds

TO THE EDITOR:

Permit me to augment my remarks on the subject of arc welding which appeared in the August issue of MECHANICAL ENGINEERING, p. 582, and were there credited to *The Engineer*, May 13, 1932.

Metallurgists have long known that the physical properties of cast-steel structures can be improved by annealing. An attempt was therefore made to treat in a similar manner the physical properties of welds, which, after all, are cast structures. It was found, however, that annealing did not always produce an improvement, but on the contrary made things worse in certain instances. The reason for this was never completely explained.

In the course of time, however, it was found from actual practice that autogenous welds are usually improved by annealing, and in any event are not made worse, while in the case of electric welds, annealing may impair them. It is only in exceptional cases that an electric weld is improved by annealing. An impression has therefore been created that the cause of welds becoming worse as a result of annealing lies in the presence of nitrogen, which is found in electric welds in larger proportions than in acetylene welds. The correctness of this view is supported by the investigations, among others, of Prox and Schuster. From these investigations it would appear that as a rule the physical properties of autogenous welds can be improved by annealing, whereas annealing can be profitably used on electric welds only if these welds have been kept free from nitrogen by the application of some special process, such as covering of electrodes, protective atmospheres, etc.; but that in the case of electric welds with higher contents of nitrogen, as is usually the case, it is better to abstain from annealing, as this will not improve the weld but will make it worse than before.

DR. ING. A. FRY.[10]

Essen, Germany.

[8] President Rose Polytechnic Institute, Mem. A.S.M.E.

[9] Jun. A.S.M.E.

[10] Fried. Krupp A-G.

BOOK REVIEWS AND LIBRARY NOTES

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Faraday and His Metallurgical Researches

Faraday and His Metallurgical Researches, With Special Reference to Their Bearing on the Development of Alloy Steels. By Sir Robert A. Hadfield, Bt. Cloth, 329 pp., 6 × 9½ in., 68 plates, 12 illus., and 27 tables. Published by Chapman & Hall, Ltd., London, 1931; distributed in America by The Penton Publishing Co., Cleveland; $6.50 postpaid.

Reviewed by Bradley Stoughton[1]

THE author of this volume is the world's foremost living metallurgist, a position which he has occupied for many years. He is the inventor of the pioneer alloy steel in the group forming the world's most efficient and useful materials in the present era, which some authorities have suggested should be called the "Age of Alloy Steels." In addition, he has to his credit the invention and development of the silicon transformer steel now almost universally used in high-permeability magnet cores in the best electrical alternating-current apparatus. It is said that the increased efficiency of this type of steel over any other material for magnet cores for alternating currents has saved, since its inception in 1905, more money in the operation of electrical machinery than would pay the whole cost of the Panama Canal.

Sir Robert Hadfield is therefore preeminently qualified to evaluate the importance of Faraday's researches in alloy steels during the years 1819–1824. One of the most important objects achieved by this book is the vital stimulus it gives to the younger metallurgists of today, not only by the emphasis properly laid on the painstaking industry and energy of Faraday, whom the author calls "the greatest experimental investigator the world has ever known," but also by the skill and perseverance displayed by the author himself and his laboratory staff in the very difficult examination of the small specimens of Faraday's alloys available for study and evaluation. A large part of this volume is appropriately dedicated to discussion of Faraday's work and a summary in the author's brilliant manner of the importance and interest of Faraday's experiments in this field, pointing out that in Faraday's time the industrial world was not ready for these materials of unusual quality and excellent strength, toughness, electrical and magnetic properties, etc. One of the chapters is devoted to "Later Developments of Alloy Steels," and alone would make the book of inestimable value for reference purposes, and for the information of all those who are interested in the improvement of the engineering materials of the day.

But the book does not confine itself to Faraday's work on alloy steels: A complete biography has not been attempted, but the author, in a characteristic fashion, exemplified in more than one other book published by him, has collected data of extraordinary interest regarding the scientists who were contemporaries or fellow-workers with Faraday, and has also outlined the series of events that led Faraday to the study of alloys of iron, which his keen vision recognized, even in that early day, as having unusual opportunities for providing science with materials which later Hadfield himself, and many other workers of the twentieth century, have developed and applied for the benefit of the so-called "Machine Age."

The book is beautifully and profusely illustrated with specimens and scenes incidental to Faraday's work, and also with an unusually good collection of portraits of scientists in the late eighteenth and the nineteenth centuries.

For all those who take pleasure in reading of the work and mental development of a great man, and for those who are interested in the development and evolution of a class of materials like alloy steels, which has done so much to improve the reliability, safety, and efficiency of modern railroads, automobiles, airplanes, electrical, and other machinery, this book will prove a welcome addition to the library.

[1] Professor in Charge, Department of Metallurgical Engineering, Lehigh University, Bethlehem, Pa.

Development of American Industries

The Development of American Industries. By John G. Glover and William B. Cornell. Prentiss-Hall, Inc., New York, 1932. Cloth, 6 × 9 in., 932 pp., 96 figs., $5.

Reviewed by Carle M. Bigelow[2]

THIS book contains a description of the development of American industry from the first days of settlement, and in many instances covers the earlier history of development of the particular industries in Europe. Thirty-nine basic industries are covered, principally those dealing with raw materials, although the chapters covering the machine-tool, automotive, and radio industries deal with fabricated products. The service industries are covered in the chapters on retailing, hotels, travel, automobile associations, banking, and trade associations. It is perhaps unfortunate that the construction industry is not convered, although its wide ramifications would make it a difficult one to deal with.

In the preface the authors state that their work is really a

[2] President, Bigelow, Kent, Willard & Co., Boston, Mass. Mem. A.S.M.E.

history of industrial economy in the United States, and the thoughtful reader can indeed find material that vividly portrays the changing panorama of industrial America.

Considering the growing appreciation of the importance of man power, the first chapter very aptly deals with labor's contribution to American industries. William Green, president of the American Federation of Labor, has prepared this chapter, which is particularly broadminded in its scope and which might well have been titled "A Philosophy of American Management." It deals with the economics of industry, rather than the labor viewpoint alone.

In the treatment of the various industries, not only are the subjects covered in an interesting manner from the historical viewpoint, but many vital statistics are included. To any one interested in a particular industry, the subject-matter will provide him with a splendid background of conditions in industry as a whole.

The final chapter, on trade associations, is not only a historical exposition of the theory of trade organizations in this country, but defines the scope of various trade activities excellently and contains a valuable review of the essentials of anti-trust legislation.

While much valuable technical information is included, the subject-matter is interestingly presented, and the book is most readable.

To any one engaged in any of the industries covered it will prove of real interest; it should also find a place in the library of the consulting engineer and student of engineering.

The Internal-Combustion Engine

THE INTERNAL-COMBUSTION ENGINE. By D. R. Pye. Oxford University Press, New York, 1932. Cloth, $6^1/_2 \times 9^1/_2$ in., 250 pp., illus., $4.

REVIEWED BY C. F. TAYLOR[3]

MOST writers on the subject of the internal-combustion engine err by attempting to cover too much ground. Single volumes dealing with everything from thermodynamics to economics, with voluminous descriptions of current engines thrown in for good measure, are not uncommon. These are uniformly disappointing to the serious student of the subject, and a book like Mr. Pye's, which frankly deals with only one aspect, but covers it in a thorough and competent manner, is therefore especially welcome.

Mr. Pye's chosen subject, that of the fundamental principles of combustion and thermodynamics of the various forms of the internal-combustion engine, is covered with exceptional thoroughness. His own researches, his association with Ricardo, and his present position as deputy director of Scientific Research of the British Air Ministry, enable him to speak with the authority of a recognized leader and to quote facts from first-hand knowledge.

The subject is treated in seven chapters, covering, respectively, introductory principles, engine cycles, fuels, detonation, combustion, thermal efficiency, and engine testing. Under each heading the fundamental relations and differences between the three major cycles, namely, those of the gasoline engine, the gas engine, and the compression-ignition engine, are thoroughly covered. Data from significant research are included wherever necessary to support the principles set forth. If one could venture a criticism, it would be that Mr. Pye might have drawn examples more freely from some recent significant American research work, especially that of the U. S. Bureau of Standards and the Society of Automotive Engineers.

Altogether, the book is quite the best work of its kind which the reviewer has yet seen, and should be welcomed by every serious student and scientific worker in the field of the internal-combustion engine.

[3] Professor of Aeronautical Engineering, Massachusetts Institute of Technology, Cambridge, Mass.

Monuments of Early Engineering

TECHNISCHE KULTURDENKMALE: im Auftrag der Agricola-Gesellschaft beim Deutschen Museum herausgegeben von Conrad Matschoss und Werner Lindner, unter Mitarbeit von August Hertwig, Hans v. u. zu Loewenstein, Otto Petersen, und Carl Schiffner. Verlag F. Bruckmann A.-G., Munich, G. E. Stechert & Co., New York, agents, 1932. Cloth, $8^3/_8 \times 11^3/_8$ in., 127 pp., 248 figs., $1.65.

REVIEWED BY HARRISON W. CRAVER[4]

THE present century has seen a great awakening of interest in the history of engineering. Nowhere has this interest been more active than in Germany, where Dr. Oskar von Miller, the head of the great Deutsches Museum, and Dr. Conrad Matschoss, the secretary of the Verein deutscher Ingenieure, have actively stimulated the study of early engineering and the preservation of early machinery and tools.

This new book, presented under the auspices of the Museum, is intended to arouse general interest in the preservation of those memorials of former engineering which still exist in Germany. Scattered over the country there still are examples of ancient wharf cranes, wind and water mills, mines, blast furnaces, foundries, bridges, and workshops. To awaken the public to the historical and cultural value of these relics, with a view to their preservation, is the purpose of the present volume.

The evolution of German metallurgy, building, mining, and millwork is briefly recounted in popular fashion by Dr. Matschoss and his collaborators. The outstanding feature of the book is, however, the illustrations. Nearly two hundred and fifty in number, they are excellent reproductions of early engines, mills, mines, foundries, and furnaces, bridges, workshops, and other works of interest to engineers, which are still extant.

Aside from its primary purpose, the book has interest for engineers of all countries. A pleasant hour can be spent over these pictures, which show more clearly than many words how grain was ground, rivers were crossed, and metals mined, smelted, and worked in the sixteenth and seventeenth centuries. Every student of the history of engineering will wish to have the book.

Books Received in the Library

ACOUSTICS AND ARCHITECTURE. By P. E. Sabine. McGraw-Hill Book Co., London and New York, 1932. Cloth, 6×9 in., 327 pp., illus., diagrams, charts, tables, $3.50. Dr. Sabine discusses such subjects as reverberation, architectural acoustics, sound transmission and absorption, machine isolation, and the control of noise in buildings. The principles underlying sound control are discussed and the results of much research work, especially that carried on by the Riverbank Laboratories, are presented.

AMERICAN SOCIETY FOR TESTING MATERIALS. Report of Committee D-2 on Petroleum Products and Lubricants and Methods of Test Relating to Petroleum Products. A.S.T.M., Philadelphia, 1932. Paper, 6×9 in., 286 pp., illus., diagrams, charts, tables, $1.25. The committee report and the forty-three methods for testing petroleum and its products which the society has accepted as standards are here conveniently brought together. The methods are complete to June, 1932, and include the latest forms of the methods for flash and fire points, cloud

[4] Director, Engineering Societies Library, New York, N. Y.

and pour points, and viscosity; the new method for the distillation of gasoline; and revised methods for testing the color of lubricating oils, specific gravities, and vapor pressures.

ASSOCIATION INTERNATIONALE POUR L'ESSAI DES MATÉRIAUX (International Association for Testing Materials). Congrès de Zurich, September 6–12, 1931. Two volumes. Association Internationale pour l'Essai des Matériaux, Zurich, Switzerland, 1932. Cloth, 7 × 11 in., vol. 1, 708 pp.; vol. 2, 1213 pp.; illus., diagrams, charts, tables, 60 Swiss frs. to members, 80 Swiss frs. to non-members. The papers, discussions, and addresses presented at the Congress are published in extenso in these handsome volumes, which contain much information upon the testing of cast-iron, stone, cement, concrete, reinforced concrete, asphalt, bitumens, fuel, and timber. Other general topics include fatigue, impact tests, the progress of metallography, the aging of organic substances, viscosity, the calibration of testing machines, and the fundamental and test relations between elasticity and plasticity, toughness and brittleness. One hundred and thirteen papers were presented. These are published in French, English, or German, with abstracts in all three languages.

COMMON SENSE APPLIED TO MOTION AND TIME STUDY. By A. H. Mogensen. McGraw-Hill Book Co., New York and London, 1932. Cloth, 6 × 9 in., 228 pp., illus., diagrams, charts, tables, $2.50 (free to subscribers of *Factory and Industrial Management*). A very interesting and useful discussion of this important topic is presented in this volume, which is based upon a course given by the author at the Massachusetts Institute of Technology and upon contributions by various hands to *Factory and Industrial Management*. The principles and methods of motion study and time study are explained and their application to various activities, such as the job shop, the department store, group work, plant layout, and machine and tool design, is illustrated from practice. The use of motion pictures is considered in detail.

COMPANY PLANS FOR UNEMPLOYMENT RESERVES. Chamber of Commerce of the United States, Department of Manufacture, Washington, D. C., 1932. Paper, 6 × 9 in., 42 pp., tables, gratis. To assist employers who desire to devise means for protecting their staffs from unemployment, the Chamber of Commerce of the United States has issued this pamphlet. In it are discussed the purpose and advantages of company reserve plans, the coverage and experience of existing plans, procedures for establishing plans, and the development of uniform plans by industries or communities.

HANDBOOK OF CHEMISTRY AND PHYSICS. Edited by C. D. Hodgman. Seventeenth edition. Chemical Publishing Co., Cleveland, Ohio, 1932. Leather, 5 × 7 in., 1722 pp., tables, $6. In this edition the Handbook has undergone an unusually extensive revision which has resulted in an addition of one hundred and fifty pages of new matter. Especially, one thousand new compounds have been added to the table of physical constants of organic compounds, which now includes over four thousand substances, and the former data carefully corrected. The mathematical section has been enlarged by adding several useful tables, and numerous new tables have been added to all divisions of the book. One hundred and twenty-five physicists and chemists have here assisted in preparing one of the most practical and useful reference works available.

HANDBOOK OF INDUSTRIAL TEMPERATURE AND HUMIDITY MEASUREMENT AND CONTROL. (Manual of Instrumentation.) Parts 2 and 3. By M. F. Béhar. First edition. Instruments Publishing Co., Pittsburgh, 1932. Cloth, 6 × 10 in., 309 pp., illus., diagrams, charts, tables, $4. Having presented the fundamentals of industrial instrumentation in his first volume, Mr. Béhar now takes up two subjects of great industrial importance: the measurement and control of temperature and of humidity. A great amount of detailed information is presented upon thermometers, pyrometers, heat recorders and controllers, and instruments for measuring and controlling humidity. Together with detailed descriptions of the principal instruments on the market, the book sets forth the general principles underlying them. The presentation is intensely practical and will be helpful to all students of these subjects.

INDUSTRIAL MANAGEMENT IN THIS MACHINE AGE. By F. A. Westbrook. Thomas Y. Crowell Co., New York, 1932. Cloth, 6 × 9 in., 407 pp., charts, tables, $3.50. The various functions of management are discussed and the principles that industry has accepted as sound are very clearly presented in this readable work, and the application of these principles under various conditions and in different lines is shown by numerous examples from actual practice. The book is intended for the business man and plant manager rather than for use as a textbook.

DIE KORROSIONSSCHWINGUNGSFESTIGKEIT VON STÄHLEN UND IHRE ERHÖHUNG DURCH OBERFLÄCHENDRÜCKEN UND ELEKTROLYTISCHEN SCHUTZ. (Mitteilungen des Wöhler-Instituts Braunschweig, Heft 10.) By E. Hottenrott. N.E.M.-Verlag, Berlin, 1932. Paper, 6 × 8 in., 62 pp., illus., diagrams, charts, tables, 3.60 rm. This pamphlet is a report of an investigation of the part played by corrosion in reducing the fatigue resistance of various steels. It reviews briefly previous investigations of the question, describes apparatus for testing specimens exposed simultaneously to corrosion and repeated stresses, and gives the results of tests upon carbon steels. The effect of cold rolling upon corrosion is also discussed.

DIE METHODEN ZUR ANGENÄHERTEN LÖSUNG VON EIGENWERTPROBLEMEN IN DER ELASTOKINETIK. (Ergebnisse der Mathematik und ihrer Grenzgebiete, Vol. 1, No. 4.) By K. Hohenemser. J. Springer, Berlin, 1932. Paper, 6 × 10 in., 89 pp., diagrams, charts, tables, 10.50 rm. This monograph first discusses the general methods of linear integral equations of the second kind and their application to the vibration of elastic bodies. It then takes up important special problems, such as vibration in rods, plates, and frameworks, and the critical speed of shafts. The book is intended to give engineers a survey of general methods for solving vibration problems and to provide mathematicians with an account of the uses of the method in practice.

PRIVATE AND COMMERCIAL MOTOR BODY BUILDING. By H. J. Butler. Isaac Pitman & Sons, London & New York, 1932. Cloth, 6 × 9 in., 248 pp., illus., diagrams, tables, $3.50. The construction of the wooden framing and the roofs of passenger cars, motor buses, and trucks is treated in full detail in this book, which also contains chapters on design, fittings, painting, trimming, repairs and costing. The information is presented clearly, and represents the best English practice.

NEW DEAL. By Stuart Chase. Macmillan Co., New York, 1932. Cloth, 6 × 8 in., 257 pp., tables, $2. Mr. Chase first chronicles the facts of the world depression, examines the course of the business cycle, and enumerates what he conceives to be its major causes. The economic system as we have known it is, he suspects, ended. He then presents his views upon the various remedies that have been proposed and, finally, suggests the path that he believes the best.

OIL ENGINE TRACTION (Howard Lectures). By A. E. L. Chorlton. Royal Society of Arts, London, 1932. Paper, 7 × 10 in., 79 pp., illus., diagrams, charts, tables, 3 s. Contains a series of four lectures delivered before the Royal Society of Arts in March, 1932. The first lecture discusses the applications that have been made of the oil engine to railway and road traction, and the results obtained. The second describes the development of the oil engine for traction, and the remaining two various electric, gear, and fluid transmissions for oil locomotives. The lectures afford a concise picture of current conditions.

PLASTIC WORKING OF METALS AND POWER-PRESS OPERATIONS. By E. V. Crane. John Wiley & Sons, New York, 1932. Cloth, 6 × 9 in., 326 pp., illus., diagrams, charts, tables, $4. Most past studies of the mechanics of materials have been concerned with the properties of metals below their elastic limits. The present book aims to assemble and develop theoretical data on their properties in the plastic range. Metal-working operations are classified into groups, such as shearing, bending, expanding, contracting, drawing, and extruding; the characteristics of each are discussed, and a theory developed for figuring operations and predicting results. Much is presented upon the press working of metals which is not elsewhere available in connected form.

POWER PLANT ENGINEERING AND DESIGN. By F. T. Morse. D. Van Nostrand Co., New York, 1932. Cloth, 6 × 9 in., 813 pp., illus., diagrams, charts, tables, $6.50. The aim of this book is to present in one volume a study of electric generating stations, including public-service, industrial, and institutional plants. Attention is paid to both mechanical and electrical features and to economic factors. Steam plants are given most attention, but hydroelectric and Diesel-engine plants are also considered. By assuming that the student has a basic knowledge of thermodynamics and mechanics and by omitting minor details of plant equipment and layout, the author has been able to compress a comprehensive account into one volume.

Erratum

ON PAGE 853 of the December, 1932, issue of MECHANICAL ENGINEERING the name of the manufacturer of the Velox boiler was incorrectly given. It should have been Brown, Boveri & Co., Ltd., of Baden, Switzerland.

CURRENT MECHANICAL ENGINEERING LITERATURE

Selected References From The Engineering Index Service

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AIR PREHEATERS

RECUPERATIVE. Verbesserung des Waermeaustausches in Rekuperativ-Luftvorwaermern, Harraeus. Feuerungstechnik v 20 n 9 and 10 Sept 15 1932 p 133–5 and Oct 15 p 149–52. Improvement of heat exchange in recuperative air preheaters; comparison of various means which have been employed for improving heat transmission by conduction, convection, and radiation.

AIRPLANES

BRAKES. Dunlop Aircraft Brake. Engineering v 134 n 3468 July 1 1932 p 10–12; see also Automotive Industries v 67 n 4 July 23 1932 p 110–11. Pneumatic brake is interesting example of this type of apparatus; apart from being extremely light, it is self-adjusting for wear, and embodies differential control operated by movement of rudder bar or pedals.

WINGS. Ueber eine einfache Moeglichkeit zur Auftriebserhoehung von Tragfluegeln, E. Gruschwitz and O. Schrenk. Zeit fuer Flugtechnik u Motorluftschiffahrt v 23 n 20 Oct 28 1932 p 597–601. Tests on wing with trailing-edge flap to increase lift and reduce landing speed.

AIRSHIPS

DESIGN. Luchtschepen voor lange afstanden, C. P. M. M. Bogaerts. Ingenieur v 47 n 40 Sept 30 1932 p V86–V93. Factors controlling suitability of airships for long-distance operation; relations between speed and size, engine power and volume, etc.; operating costs for airship service between Holland and Dutch East Indies.

ALUMINUM ALLOYS

CASTINGS. Leichtmetall-Sandguss, W. Saran. Zeit fuer Metallkunde v 24 n 8 and 9 Aug 1932 p 181–4 and Sept p 207–10. Light-metal sand castings, their static and dynamic strength; Brinell hardness, bending, torsion, and tensile strength; tests on Schenck high-frequency tension-compression machine.

AUTOGIROS

PERFORMANCE. Lift and Drag Characteristics and Gliding Performance of Autogiro as Determined in Flight, J. B. Wheatley. Nat Advisory Committee Aeronautics—Report n 434 1932 10 p. Based on sum of fixed-wing and swept-disk areas, max. lift coefficient is 0.895, min. drag coefficient with propeller stopped is 0.015, and max. lift-drag ratio with propeller stopped is 4.8; min. vertical velocity of 15 ft per sec at air speed of 36 mph and flight-path angle of minus 17 deg.

BOILERS

CONTROL. Le réglage automatique de la chaufferie d'un turbo-alternateur de 10,000 kws aux aciéries de Micheville, Priestly. Revue de Métallurgie v 29 n 9 Sept 1932 p 437–41. Automatic pressure, combustion, and draft control of boilers for 10,000-kw turbo-alternator at steel plant of Micheville, France; boiler plant consists of three boilers each having 775 sq m heating surface; sectional drawing of control equipment.

FEEDWATER ANALYSIS. Determination of hydroxide and Carbonate in Boiler Waters, E. P. Partridge and W. C. Schroeder. Indus and Eng Chem—Analytical Edition v 4 n 3 July 15 1932 p 271–283. Review of methods; development and testing of apparatus for carbonate determination by evolution and absorption in barium hydroxide; this gives accurate and consistent results for total carbon dioxide, even at low concentrations. Plant tests of various methods for determining ratios for boiler-water control; large errors in carbonate, hydroxide, and sulphate may result from poor sampling procedure and use of inadequate analytical methods. Bibliography.

FIRING. Neuerungen im Bau von Hochleistungskesseln unter besonderer Beruecksichtigung der Feuerungen, Kaiser. Maschinen-Konstrukteur v 65 n 15/16, 17/18, and 19/20 Aug 10 1932 p 91–4, Sept 10 p 101–11 and Oct 10 p 122–5. Improvements in automatic equipment for boiler firing with particular regard to pulverized coal, stokers, etc.; performance characteristics of German installations; Brown-Boveri internal-combustion steam generator operating on gas velocity of 200 m per sec, used in connection with gas turbines.

HIGH-PRESSURE. Remarkable Steam Generator. Engineer v 154 n 4005 Oct 14 1932 p 390. Generator by Sulzer Bros. will have continuous steel tube 2 in. in diam and no less than $1^1/_2$ mi long; generator under erection in textile works will have normal output of 18,000 lb per hr at pressure of 1400 lb per sq in. and will supply steam to high-pressure turbine, exhaust from which is employed for heating buildings and for process work.

OPERATION—IDLENESS LOSSES. Schutzmassnahmen fuer ausser Betrieb gesetzte Dampfkesselanlagen, Walger. Waerme v 55 n 41 Oct 8 1932 p 707–9. Means of safeguarding shut-down boiler plants; damages occurring to idle plants; dry, wet, and ammonia conservation for boilers, superheaters, economizers, air preheaters, pumps, pipe lines, feedwater-treatment plants, masonry, chimneys, etc.

PLATES—CRACKING. Ergebnisse der Untersuchung zweier ausgebauter Garbetrommeln, Ebel. Waerme v 55 n 39 Sept 24 1932 p 664–70. Results of investigation of two built-up Garbe-boiler drums; elastic stresses and crack formations; examination of flow of forces in overlapping rivets; materials testing; effect of aging and stress on lack of roundness of drums.

PLATES—FAILURE. Une étude d'ensemble sur la résistance des materiaux a employer dans la construction des chaudières—Recherche des causes d'accident des tôles de chaudières aquatubulaires, G. Paris. Chaleur et Industrie v 13 n 147 July 1932 p 475–8 3 supp plates. Notes on aging; caustic brittleness; macrographic and micrographic research of plates that have met with failure; interpretation of results.

PULVERIZED - COAL. Kohlenstaubfeuerung beim Flammrohrkessel, O. Leppin. Archiv fuer Waermewirtschaft v 13 n 10 Oct 1932 p 263–5. Pulverized-coal firing in fire-tube boiler; advantages over water-tube boilers; pulverizing plant; results of tests with different types of furnaces.

VELOX—THEORY OF. Theory of Velox Boiler. Engineering v 134 n 3486 Nov 4 1932 p 539–40. Editorial comment on Velox boiler of Brown-Boveri Co.; there is discrepancy of nearly 7 per cent which is entirely attributable to fact that data used are thermodynamically inconsistent; apparently no one has detected source of error, and by some the discrepancy has been attributed to a mysterious heat-pump effect.

BOLTS AND NUTS

FORGING. L'estampage à chaud des boulons et vis sur les presses mécaniques, J. Bertrand. Pratique des Industries Mecaniques v 15 n 7 Oct 1932 p 237–43. Dies and presses permitting reduction of weight in manufacture of bolts and nuts.

CAR AXLES

CRACKS. Achsbrueche bei Eisenbahnfahrzeugen und ihre Ursachen, R. Kuehnel. Stahl u Eisen v 52 n 40 Oct 6 1932 p 965–9. Axle cracks in railroad rolling stock and their causes; observations of German Railway Co. of fractures on corroded or welded-on parts of axles; causes of failure not due to defective material, but to unusual stresses or notch effects in joining of axle and wheel.

CARS, FREIGHT

HOPPER. Kansas City Southern Gets All-Steel Hopper Gondolas. Ry Age v 93 n 17 Oct 22 1932 p 572–4. Company has built at its shops, Pittsburg, Kan., lot of 25 all-steel general-service hopper-bottom gondolas, of 70 tons nominal capacity; use of one-piece cast-steel underframes, and superstructures made of copper-bearing steel completely fabricated by electric welding.

CARS, REFRIGERATOR

MECHANICALLY REFRIGERATED. Mechanically Refrigerated Railroad Freight Cars, H. M. Wigney. Ry Age v 93 n 14 Oct 1 1932 p 458–60. Over 100,000,000 lb of perishables of all kinds handled in three years with only $^1/_{10}$ of 1 per cent of loss; safety Diesel compression-type car; compressor is 2-cyl. machine operating at 400 rpm and has capacity of one ton (288,000 Btu in 24 hr); refrigerant is methyl chloride; mechanical vs. ice refrigeration.

CAST IRON

HEAT TREATMENT. Die Waermebehandlung des grauen Gusseisens, P. A. Heller. Giesserei v 19 n 41/42 Oct. 14 1932 p 413–19. Heat treatment of gray cast iron; critical summary of literature on subject up to end of 1930 and conclusions regarding best recommended conditions for heat treatment.

Physical Properties of Heat Treated Cast Iron, F. G. Sefing and M. F. Surls. Mich. Eng. Experiment Station—Bul n 47 June 1932 30 p. Effect of annealing temperatures on results obtained with two typical gray cast irons; effect of simple water quench and influence of quenching and reheating to common annealing temperature; importance of impact values and their lack of relationship with other physical data; photomicrographs show structural effects of various treatments used.

Some Thoughts Concerning Mixtures, Perlit Process and Heat Treatment of Cast Iron, H. J. Young. Am. Foundrymen's Assn.—Trans v 3 n 6 Oct 1932 p 325–40 (discussion) 340–3. Mixtures which can be made from stockyard containing four pig irons, steel and scrap, to produce given analysis perlit or hot-mold process in comparison with cold-mold results; photomicrographs of heat-treated irons.

TESTING. Erfahrungen bei der Abnahme von hochwertigem Grauguss, Krueger. Waerme, v 55 n 39 Sept 24 1932 p 671–6. Experiences with acceptance tests of high-grade gray cast iron; defects observed with water-pressure test, etc.; method of strength testing critically discussed; test results compared.

CHIMNEYS

DESIGN. Sul problema del tiraggo e sul proporzionamento dei camini industriali, M. Medici and G. Manzella. Politecnico v 80 n 8 Aug 1932 p 434–50. Factors controlling dimensions of industrial chimneys with particular regard to calculation of draft.

CHROMIUM-NICKEL ALLOYS

ILLIUM. Illium, W. D. Staley. Product Eng v 3 n 11 Nov 1932 p 456–7. Properties and application of nickel-chromium-copper alloys developed by Burgess-Parr Co., with particular regard to corrosion resistance; tensile strength 60,000 lb per sq in.; machinability slightly harder than cast steel.

CHROMIUM-VANADIUM STEEL

CREEP. Creep at Elevated Temperatures in Chromium-Vanadium Steels Containing Tungsten or Molybdenum, W. Kahlbaum and L. Jordan. U S Bur Standards—J Research v 9 n 3 Sept 1932 p 441–55. Determinations of creep at temperatures between 750 and 1000 F were made on two tungsten-chromium-vanadium and molybdenum-chromium-vanadium steel: these steels were tested as tempered after mechanical working (rolling), and are compared with steels of similar compositions which had been oil quenched and tempered.

COAL ANALYSIS

CALORIFIC VALUE. Selection of Coal to Meet Critical Conditions, J. E. Tobey. Power Plant Eng v 36 n 19 Nov 1932 p 746–9. As outcome of intensive study, covering period of 7 yr, during which time several thousand coal and ash analyses were made and over million tons of coal consumed in plant using extremely high furnace temperatures covering range of 2700 to 3100 F, author has formulated various precautions.

COAL-HANDLING EQUIPMENT

CONVEYORS. Gravity Bucket Conveyors. Mech Handling v 19 n 10 Oct 1932 p 347–50. Equipment at Barking power station consists of two conveyors, each having capacity of 125 tons per hr when traveling at speed of 48 ft per min; each has 906 linear ft of chain, number of buckets being 453, placed at 2-ft centers.

Richtige Unterteilung von Rutschenstraengen, H. Philipp. Bergbau v 45 n 18 Sept 1 1932 p 255–9. Proper arrangement and divisions of chute sections; diagram showing division of section under varying conditions of useful load and dead load; length of sections given in percentage figures; calculation is limited to coal-handling equipment.

SHAKING. Controlled Driving Trough for Shaker Conveyors. Engineering v 134 n 3483 Oct 14 1932 p 463. Trough designed by Mavor and Coulson is supported on two driving levers at one end and on swinging link at other.

COPPER ALLOYS

HIGH-TEST. Harte Qualitaetslegierungen des Kupfers, K. Ewig-Daues. Zeit fuer Metallkunde v 24 n 9 Sept 1932 p 214–19 (discussion) 219–20. High-test hard alloys of copper; constitution, properties and working of copper-tin bronzes, copper-aluminum alloys, and copper-zinc alloys.

CUPOLAS

BLOWERS. Constant Weight Cupola Blowers. Foundry Trade J v 47 n 845 Oct 27 1932 p 249. Development by British Thomson-Houston Co., of new cupola-blowing equipment, which greatly improves efficiency of melting operation; control equipment; constructional details of blowers.

DIE CASTING

PRESSURE. Metallpressguss, J. Mehrtens. Zeit fuer die gesamte Giessereipraxis v 53 n 37/38 Sept 11/18 1932 (Metall) p 382–4. Non-ferrous pressure casting; advantages of this type of die casting, particularly for brass and bronze castings.

DIES

STAMPING. Emboutissage d'un coffre rectangulaire en tôle d'acier, J. Bertrand. Pratique des Industries Mecaniques v 15 n 5 Aug 1932 p 175–80. Design and operation of drawing and stamping dies for making rectangular casing from sheet steel.

WELDING. Weight and Cost of Steel Dies Reduced by Use of Gas Cutting and Welding, E. Chapman. Automotive Industries v 67 n 17 Oct 22 1932 p 530–2. Building up of dies from steel plates eliminates scrapping of castings and patching of flaws.

DRYING

THEORY OF. Theory of Drying, J. Frith and F. Buckingham. Engineering v 134 n 3483 Oct 14 1932 p 460–3 and (discussion) 437. Problem of drying; theory of wet-bulb thermometer; wet-bulb thermometer as measure of total heat of any mixture of air and water vapor; relative humidities per cent calculated from theory. Before British Assn.

DIESEL ENGINES

AUTOMOTIVE. Influence of Several Factors on Ignition Lag in Compression-Ignition Engine, H. C. Gerrish and F. Voss. Nat Advisory Committee Aeronautics—Tech Notes n 434 Nov. 1932 8 p 9 supp sheets. Influence of fuel quantity, injection advance angle, injection valve-opening pressure, inlet-air pressure, compression ratio, and engine speed on time lag of auto-ignition of Diesel fuel oil in single-cyl. engine determined from analysis of Farnboro indicator diagrams.

New 410 B.H.P. Lightweight Diesel Engine, E. P. A. Heinze. Ry Gaz v 57 n 11 Sept 9 1932 p 315–16. 12-cyl. engine having two banks of six cylinders inclined at angle of 60 deg, develops 410 bhp at 1350 rpm; bore and stroke 5.9 by 7.87 in.; compression ratio 13 to 1; weight 3740 lb; roller-bearing crankshaft and overhead valves; fuel consumption, 0.39 lb per hp-hr.

DESIGN. Die Leistungssteigerung von Viertakt-Verbrennungskraftmaschinen durch Vorverdichten der Verbrennungsluft, A. Oppitz. Schiffbau v 33 n 18, 19 and 20 Sept 15 1932 p 279–82, Oct 1 p 300–3 and Oct 15 p 318–9. Increase in efficiency of 4-cycle internal-combustion engines by precompression of combustion air; fuel economic features; utilization of pressure fluctuations in air and exhaust-gas lines for precompression; steam drive and exhaust-gas drive of precompressors; mechanical and electric drive.

FUEL INJECTION. Bidrag Till Teorien for den Direkta Bransleinsprutningen Vid Forbranningsmotorer, H. O. Dahl. Teknisk Tidskrift v 62 n 42 Oct 15 1932 (Mekanik) p 113–18. Contribution to theory of direct fuel injection in internal-combustion engine, with particular regard to pressure wave and injection lag.

Rates of Fuel Discharge as Affected by Design of Fuel-Injection Systems for Internal-Combustion Engines, A. G. Gelalles and E. T. Marsh. Nat Advisory Committee Aeronautics—Report n 433 1932 15 p. Effect of variation in pump speed, pump-throttle setting, discharge-orifice diameter, injection-valve opening and closing pressures, and injection-tube length and diameter. Bibliography.

FUELS. Heavy Oils and Their Use in Internal-Combustion Engines, G. Eichelberg. Gas and Oil Power v 27 n 325 Oct 1932 p 216–18. Difficulties resulting from use of unsuitable fuels; curves showing influence of viscosity on size of fuel drops when injected into engine; compressibility of different Diesel fuels; influence of ash content and impurities.

MARINE. New-Design Four-Cycle Marine Diesel Engine, H. Rohwer. Eng. Progress v 13 n 11 Nov 1932 p 241–3. At Leipzig Spring Fair, Fried. Krupp Germaniawerft A.G., of Kiel, exhibited new type of airless-injection 4-cycle marine Diesel engine; engine has bore of 11 in., stroke of 16.6 in., and with 4 cyls., running at 428 rpm, develops output of 265 bhp.

VIBRATIONS. Torsional Vibration Characteristics of Six-Cylinder Four-Stroke Cycle Single-Acting Oil Engines, W. K. Wilson. Gas and Oil Power v 27 n 325 Oct 1932 p 213–14. Vibration-stress diagram for marine installation; normal crank and balance-weight arrangement; effect of reducing magnitude of flywheel and crankshaft balance weights.

ECONOMIZERS

OPERATING EXPERIENCES. Betriebserfahrungen an Ekonomisern und Lufterhitzern, Wagner. Waerme v 55 n 39 Sept 24 1932 p 677–80. Practical experiences with economizers and air preheaters, defects and means of improvements; results of heating tests with intermittent operation; new designs and results of acceptance tests.

PIN TYPE. Nadel-Ekonomiser und Lufterhitzer, Truelsen. Archiv fuer Waermewirtschaft v 13 n 10 Oct 1932 p 257–8. Design of so-called pin economizer and air preheater, developed by C. Amme; phenomena occurring with heat transfer to pins; results of tests; design is similar to that of ribbed-tube economizers.

RIBBED-TUBE. Gasstroemung und Waermeaufnahme bei Rippenrohr-Vorwaermern, E. Neussel. Archiv fuer Waermewirtschaft v 13 n 10 Oct 1932 p 266–70. Flow of gas and heat absorption in ribbed-tube economizers; diagram of flow; loss of draft; heat absorption with ribs of various lengths.

FLOW OF GASES

ORIFICES. Notes on Orifice Meter; Expansion Factor for Gases, E. Buckingham. U S Bur Standards—J Research v 9 n 1 July 1932 p 61–79. Discussion of recent experimental data which show how expansion factors depends on form of meter, ratio of downstream to upstream pressure, and specific-heat ratio of gas; conclusions are summarized in empirical equations which may be used for computing value of expansion factor in certain practically important cases; theoretical method of computing expansion factor. Bibliography.

FLOW OF STEAM

ORIFICES. Kritische beschouwing van de formules ter berekening van stoomhoeveelheden bij meting met stuwflenzen, H. Lameris. Ingenieur v 47 n 41 Oct 7 1932 p W139–44. Critical analysis of equations for calculation of quantities measured with orifices; equations given by Mitteilungen der Waermestelle Duesseldorf, in rules of V.D.I., and in 26th edition of Huette, are critically studied; conclusions are drawn and coefficients for saturated steam are calculated.

FORGINGS, STEEL

DEFECTS IN. Flow Lines in Forged Steel, E. W. Nelson. Heat Treating and Forging v 18 n 8 and 9 Aug 1932 p 465–7 and Sept p 529–30 and 534. Formation of flow lines in wristpins, crankshafts, and gears as controlled by manufacturing methods.

FURNACES, FOUNDRY

PULVERIZED-COAL. New Steel-Making Process, V. C. Faulkner. Foundry Trade J v 47 n 843 Oct 13 1932 p 219 and 228. Use of pulverized-fuel-fired rotary furnace at Mons Foundry Co., in Belgium, for manufacture of small steel castings; comparison made between this new method and with established methods of melting; cost of installation; raw materials; labor; refractories; quality.

FURNACES, HEAT-TREATING

AUTOMATIC. Automatic Furnace for Heat Treatment of Medium and Heavy Plates, H. Fey. Eng Progress v 13 n 11 Nov 1932 p 243. Furnace enables plates of between 0.320 and 4.80 in. gage, and up to 12 tons weight of single piece, to be heat treated, starting with work either hot or cold; blast-furnace gas of from 96 to 110 Btu per cu ft is available at plant; may be enriched to 120 Btu per cu ft by admixture of coke-oven gas; max. output of furnace is 30 tons per hr when starting from hot, and 20 tons starting from cold work.

FORGE SHOPS. Heat Treating Furnaces in Forge Shops, R. R. La Pelle. Heat Treating and Forging v 18 n 9 Sept 1932 p 539–42. Various types of electric and fuel-fired furnaces used in modern forge plants for heat treating forgings, including pusher-type furnaces for heavy forgings, furnaces for special annealing cycles on alloy steels, continuous-conveyor furnaces for small parts, etc.

GAS COMPRESSORS

ROTARY. Rotary Compressor With Controlled Blades. Engineering v 134 n 3480 Sept 23 1932 p 371. Design developed by Daniel Foxwell & Son; blades are constrained so that their outer edges are just clear of cylinder, minute space between two surfaces being sealed by oil film; it is claimed that by use of controlled blades, machine gives greater output relatively to its

power consumption than would be otherwise possible.

GASES

HIGH PRESSURES—MEASUREMENT. Twin-Bomb Method for Accurate Determination of Pressure-Volume-Temperature Data and Simple Method for Accurate Measurement of High Pressures, E. W. Washburn. U S Bur Standards—J Research v 9 n 2 Aug 1932 p 271–8. Outline of method which will probably find its chief application in chemical laboratories and industrial laboratories which do not have available accurate deadweight pressure gages, but which occasionally need *P-V-T* data for gases and vapors and their mixtures; equipment and procedure.

HEAT ENGINES

MIXED-VAPOR. Maxwell's Demons Drive My Mixed Vapour Engine, A. Irinyi. Steam Engr v 1 n 3 and 4 Dec 1931 p 119–20 and 126 and Jan 1932 p 173–5. Author has endeavored to find new way to compel condensation to take place in working chamber of engine between two limiting temperatures; principles upon which mixed-vapor (benzol and water) engine is based.

Zwei neue Wege zur Krafterzeugung, G. Jungnitz. Waerme v 55 n 40 Oct 1 1932 p 692–4. Two new ways of generating power; peculiarities of methods proposed by A. Irinyi and Malone are critically discussed; former, using mixed-vapor engine employing water and benzol vapor, is stated to be based on unsound physical principles; whereas Malone's process, employing water-expansion engine, is economically sound; it is based on principle of old hot-air engine, air being replaced by liquid water.

HEAT EXCHANGERS

HEAT TRANSFER IN. Fluid Friction and Heat Transfer, C. M. White. Chem Age v 27 n 694 Oct 15 1932 p 360–1. Points in design of heat exchangers; certain methods by which heat-transfer coefficients may be predicted from fluid friction data; basic area of Reynolds' analogy; mass interchange; axial flow through tubes; influence of rate of heat flow. Before Instn. Chem. Engrs.

HEAT STORAGE

MOLTEN-SALT SYSTEM. "N.S." Molten Salts, D. Brownlie. Steam Engr v 11 n 2 Nov 1932 p 55–7. New type of liquid for heat storage and interchange, known as "N.S." molten salts; process controlled by Heinrich and Holzhuet, Berlin, is invention of E. Sander and W. Nocon; salts are mixture of aluminum chloride, sodium chloride, and ferric chloride used in closed circuit in absence of air; it is claimed mixture can be used continuously without decomposition at over 1832 F, remaining liquid throughout; boiling point under atmospheric pressure is much above 1472 F.

HEAT TRANSMISSION

PROBLEM IN. Application of Heaviside's Operational Method to Solution of Problem in Heat Conduction, S. Goldstein. Zeit fuer Angewandte Mathematik und Mechanik v 12 n 4 Aug 1932 p 234–43. Determination of temperature at any time at any point of given solid body, which at given instant is at given constant temperature and is placed in medium at another given, lower, constant temperature, into which radiation takes place from surface of solid body. (In English.)

SURFACE. Schlierenaufnahmen des Temperaturfeldes in der Naehe Waermeabgebender Koerper, E. Schmidt. Forschung auf dem Gebiete des Ingenieurwesens v 3 n 4 July-Aug 1932 p 181–9 4 supp plates. Photographic determination of temperature field in neighborhood of heat-transmitting body; shadow-projection method for quantitative evaluation of temperature field and heat flow; theory of light diffraction by temperature field around heated bodies.

HYDRAULIC TURBINES

CAVITATION. Cavitation in Large Hydraulic Turbines, H. A. Sieveking. Engineering v 134 n 3484 Oct 21 1932 p 486. Example of runner damaged through cavitation after 14,960 hr running time; it is of special cast bronze with blades cast integrally; there is definite relationship between head under which unit operates, draft head, and specific speed, all three of which have to be borne in mind when designing hydraulic power station.

KAPLAN. Low-Head Hydroelectric Developments, A. V. Karpov. Am Inst Elec Engrs—Advance Paper n 32-129 mtg Oct 10-13 1932 14 p. General ideas about Francis, propeller-type, and Kaplan turbines in low-head developments; important points with respect to cavitation and pitting; modern design theories; design of propeller and Kaplan turbines; research requirements and practice; practical application of theories demonstrated by table of designs.

HYDRODYNAMICS

FLOW ANALYSIS. Mehrdeutige Loesungen bei Potentialstroemungen mit freien Grenzen, S. Bergmann. Zeit fuer Angewandte Mathematik u Mechanik v 12 n 2 Apr 1932 p 95–121. Theoretical mathematical analysis of two-dimensional irrotational flow with free boundaries; numerical examples.

HYDROELECTRIC POWER DEVELOPMENTS

CANADA. Chats Falls Hydroelectric Power Developments, R. F. Legget. Civ Eng (Lond.) v 26 n 315 Sept 1932 p 20–3. Principal features of 10-unit hydroelectric power development which will ultimately have capacity of 280,000 hp, operating under average head of 53 ft; construction procedure under severe winter conditions.

HYDROELECTRIC POWER PLANTS

PUMPED-STORAGE. Energiespeicherung durch Pumpen, A. Engler. Assn Suisse des Electriciens—Bul v 23 n 19 Sept 16 1932 p 502–9. History of pumped-storage practice, with special reference to Switzerland; economics of pumped storage; operation of pumps; electromechanical installations.

INDUSTRIAL POWER PLANTS

PURCHASED VS. GENERATED POWER. Industrial Diesel Plants—When Are They Justified? H. C. Thuerk. Elec World v 100 n 15 Oct 8 1932 p 494–7. Analysis of fundamental economic questions in successfully meeting Diesel-engine competition; competition of Diesel engine, based as it is on striking claims of savings through its use, must be met by thorough analysis of customer's overall power costs, which includes determination of all running and overhead expenses and close examination of labor requirements. Before Nat. Elec. Light Assn.

INTERNAL-COMBUSTION ENGINES

EFFICIENCY. A propos du rendement mécanique des machines à mouvement alternatif, O. Lepersonne. Revue Universelle de Mines v 75 n 9 Nov 1 1932 p 257–71. Mechanical efficiency of machines with reciprocating movement; method of calculating efficiency of such machines applied to 4-cyl internal-combustion engine at high speed, this being one of most complex cases; formulas for calculation of mechanical power losses; determination of influence of different factors on mechanical efficiency.

VALVES. Ventilsteuerung mit Oelgestaenge, W. Stieber. Zeit fuer Flugtechnik und Motorluftschiffahrt v 23 n 18 Sept 28 1932 p 536–9. Tests on single-cyl engine with hydraulic valve gear illustrate advantages obtained by elimination of push rod and play in operation of overhead valves.

IRON AND STEEL

MACHINABITITY. Stand der Kenntnisse ueber die Zerspanbarkeit von Stahl und Gusseisen, F. Rapatz. Stahl u Eisen v 52 n 43 Oct 27 1932 p 1037–45. Status of knowledge of cutting properties of steel and cast iron; estimation of machining properties according to time, cutting-speed curves, surface appearance of workpiece and power requirement; influence of mechanical properties of steel and cast iron on lathe cutting; influence of high-speed-steel tools and cutting metal.

LOCOMOTIVES

BEARINGS. Large American Locomotives With Roller Bearing Equipment. Ry Gaz v 57 n 18 Oct 28 1932 p 519–20. Delaware & Hudson Railroad placed in service freight locomotive of 4–8–0 type, having driving and coupled axles equipped with roller bearings; bearings were of S.K.F. spherical roller type of 11.8110 in. bore × 22.0472 in. outside diam × 6.6929 in. wide; New York Central Railroad also placed in service 4–6–4 Hudson locomotive equipped with S.K.F. spherical roller bearings.

New York Central Locomotive No. 5343 Makes Over 130,000 Miles, H. E. Brunner and B. W. Taylor. Ry Age v 93 n 13 Sept 24 1932 p 421–5. 4–6–4 Hudson-type passenger locomotive; engine-truck, driving and tender-truck journals equipped with S.K.F. bearings; tractive force 42,300 lb, cylinders 25 in. by 28 in., driving-wheel diam 79 in., steam pressure 225 lb, total weight in working order 656,500 lb, total engine and tender wheelbase 83 ft 7½ in.; typical runs.

DESIGN. Steam Locomotive Design: Data and Formulae, E. A. Phillipson. Locomotive v 38 n 482 Oct 15 1932 p 353–5. Design data on axle-box journals; side thrust on axles; stresses in crank-axle webs and pins; built-up crank axles.

DIESEL-ELECTRIC. Motive Power Equipment in United States Using Electric Transmission with Internal-Combustion Engines, H. L. Andrews. Gas and Oil Power v 27 n 325 Oct 1932 p 226–7. Fuel and maintenance costs for steam and Diesel-electric locomotives in industrial and railroad switching service.

ELECTRIC. New Swiss Electric Locomotives. Ry Gaz v 57 n 15 Oct 7 1932 p 430–2. Two locomotives, Nos. 11801 and 11851, built by Swiss Locomotive & Machine Works of Winterthur for service on St. Gotthard route of Swiss Federal Railways; driving-wheel diam. 63.38 in. and 53.15 in. respectively; 8 and 16 traction motors; max. tractive effort 110,000 lb and 132,000 lb; continuous hp 6910 hp at 37.9 mph and 8190 hp at 40.0 mph; max. speed 62.1 mph; considered more powerful than any other steam or electric locomotive in world.

Performances of New York Central Electric Freight Locomotives, F. H. Craton and J. F. Walker. Ry Age v 93 n 16 Oct 15 1932 p 530–2. Test results warrant rerating of electric units and show them to be suitable for both freight and passenger service; adhesion and train friction.

FRANCE. Four-Cylinder Compound Freight Locomotive, P. L. M. Ry. Locomotive v 38 n 481 and 482 Sept 15 1932 p 305–8 and Oct 15 p 344–8. 2–10–2 4-cyl. compound freight locomotive, No. 151A-1, of Paris, Lyons & Mediterranean Ry has outside 4-cyl. balanced-compound fully coupled engine; five coupled axles are divided into two groups, of which leading group comprises two axles, second pair of wheels taking drive from leading cylinders; design details, sectional elevation and plan of locomotive engine.

MACHINE DESIGN

STRESSES. Das Dehnungslinienverfahren, O. Dietrich and E. Lehr. VDI Zeit v 76 n 41 Oct 8 1932 p 973–82. Investigation of stress distribution and fatigue effect of alternating loads by method of Maybach-Motorenbau; stress concentration in crankshafts, crankcase, and other parts of airship engine.

MACHINE TOOLS

DYNAMOMETERS. New Tool Dynamometer for Machine Tools, Y. Sekiguchi and I. Hasegawa. Soc Mech Engrs, Japan—J v 35 n 185 Sept 1932 p 914–23. Dynamometers used for measuring cutting force classified in two groups, hydraulic and piezoelectric; in dynamometer devised by authors, recording of cutting force is carried out by purely mechanical method; rectangular bar is twisted by force and its angular displacement magnified by levers and recorded. (In Japanese, with English abstract p S-14–5.)

MACHINERY FOUNDATIONS

VIBRATIONS. Schwingungen von Maschinenfundamenten, J. Baechtold. Schweiz Bauzeitung v 100 n 13 Sept 24 1932 p 167–9. Theoretical mathematical discussion of vibrations in foundation frames of steam turbines and similar heavy machinery.

MATERIALS HANDLING

CABLEWAYS. Les appareils modernes de manutention mécanique, M. Pelou. Science et Industrie v 16 n 224 Sept 1932 p 385–95. Cableways discussed under heads: loading and unloading stations; rolling equipment; installation; maintenance; conclusions with regard to single and double cableways; summary description of some installations.

FLOUR MILLS. Mechanical Handling in Flour Milling Industry, P. I. Smith. Mech Handling v 19 n 10 Oct 1932 p 343. At large Continental mill, Grands Moulins de Paris, grain arrives by barges and is unloaded by means of elevator boot; grain is then discharged on to belt conveyor; discharge is effected by pneumatic-transport installation; automatic scales used.

MECHANICAL ENGINEERING

SOCIOLOGICAL ASPECTS. More Majorum. Engineer v 154 n 4008 Nov 4 1932 p 459. Editorial comment on address by W. Taylor before Institution of Mechanical Engineers; deals only with that part of address which comments on sociological effects of mechanization; in satisfaction of vast multitude, mechanical engineer who has made mass production of cameras possible has far more than compensated for depriving the rare dilettante of his ecstacy.

METALS

COLD WORKING. Die Erholung von den Folgen der Kaltbearbeitung, G. Tammann. Zeit fuer Metallkunde v 24 n 9 Sept 1932 p 220–3. Recuperation of metals after effect of cold working; results of series of investigations of copper, silver, and gold; aluminum; iron and nickel; palladium and platinum.

CUTTING—FINISHES. Oberflaechenguete, H. Ragotzi. Werkstattstechnik v 26 n 16 Aug 15

1932 p 315–18. Comparison and testing of finishes obtained by diamond cutting, lapping, and grinding with various grit sizes and polishing according to papers by J. Gaillard, R. E. W. Harrison, and R. C. Deale.

FATIGUE CRACKS. Fatigue Cracks and Their Propagation, A. Thum and H. Oschatz. Metallurgist (Supp to Engineer) Oct 28 1932 p 155–6. Direction of propagation and its relation to type of stress and form of test piece, i.e., to stress distribution; investigation of path of crack; use of method for predicting course of fatigue cracks and determining effect of alterations of section, also means of deducing from crack, stress distribution in part which is not susceptible to mathematical treatment.

RECRYSTALLIZATION. Kaltverformung, Kristallerholung und Rekristallisation, H. Reischauer and F. Sauerwald. Metallwirtschaft v 11 n 43 and 44 Oct 21 1932 p 579–81 and Oct 28 p 591–3. Cold forming, crystal recovery, and recrystallization; cold deformation and strain hardening; state of cold-worked material from standpoint of grid geometry, atomic stresses; and from standpoint of kinetic theory, electron theory and atomic physics.

WEAR. Zur Theorie der Reiboxydation, M. Fink and U. Hofmann. Archiv fuer das Eisenhuettenwesen v 6 n 4 Oct 1932 p 161–4. Theory of frictional oxidation; analysis of dust resulting from abrasion due to rolling friction of copper, electrolytic iron and nickel; abrasion with rolling friction due to oxygen absorptivity of plastically deformed metal surface and decomposition of oxidized surface; friction oxidation as cause of fatigue embrittlement.

PIPE

HEAT TRANSMISSION. Waermeleitung im Rohr bei ungleichmaessiger Waermebelastung, A. Konejung. Zeit fuer Angewandte Mathematik und Mechanik v 12 n 4 Aug 1932 p 229–33. Theoretical analysis of heat-transmission phenomena in pipe with unsymmetrical temperature distribution; application to water-tube boilers.

PLASTICS

DIE CASTING OF. Das Spritzverfahren, eine neue Methode zur Verarbeitung von organischen plastischen Massen, C. Stark. Kunststoffe v 22 n 10 Oct 1932 p 220–1. Die-casting process a new method for treatment of organic plastic bodies; examples of equipment and methods employed.

PRESSES

HYDRAULIC. Arbeitsverhaeltnisse an einer direkt angetriebenen 1500-t Strangpresse mit 300 at Pressdruck, C. Bernhoeft. Zeit fuer Metallkunde v 24 n 9 Sept 1932 p 210–13. Operating conditions of directly driven 1500-ton hydraulic press with 300-atm pressure; various press-working processes; performance data of press for working various alloys of different rod lengths; flow phenomena.

PRESSURE VESSELS

ELECTRIC WELDING. Application of Welding to Pressure Vessels, P. R. Hawthorne. Am Welding Soc—J v 11 n 9 Sept 1932 p 19–23. Examples of welded products built in accordance with A.S.M.E. Code for Classes 1 and 2; heat treatment and testing.

PRODUCTION CONTROL

RECORDS. Arbeitsvorbereitung zur Wahl der Fertigungsmittel bei der Konstruktion, E. Eichwald. Maschinenbau v 11 n 18 Sept 15 1932 p 385–8. Preparation, layout, and classification of various records required for planning production in machine shops.

PULVERIZED COAL

COMBUSTION. La combustion du charbon pulvérisé, L. Nisolle and A. Bodmer. Technique Moderne v 24 n 14 and 16 July 15 1932 p 449–55 and Aug 15 p 518–24. July 15: Interpretation of research on combustion of pulverized coal in furnaces; ignition temperatures of various types of coal; effect of particle size. Aug. 15: Formulation of radiation phenomena and flame characteristics; temperature characteristics of combustion chambers.

PUMPING PLANTS

GREAT BRITAIN. Surbiton Pumping Station of Metropolitan Water Board. Engineering v 134 n 3484 Oct 21 1932 p 465–9. Remodeling of old station by conversion of existing plant and buildings to modern requirements in stages; turbines are of impulse type, having nine single stages with one two-row velocity wheel; pumps supplied by Worthington-Simpson are of double-suction, single-impeller, volute type; booster pumps of same type.

RAIL MOTOR CARS

DIESEL. Four Diesel-Electric Railcars for India. Ry Gaz v 57 n 15 Oct 7 1932 p 435–7. Armstrong-Whitworth Diesel-engined rail cars for 2-ft 6-in. gage lines of Gaekwar's Baroda State Railways; unit may be regarded as 4–2–0 locomotive having its frame lengthened to carry short coach body with driver's compartment on each end; hauls load of 40 tons on grades of 1 in 100 at 20 mph; 6-cyl. engine BLD type Armstrong-Saurer unit, continuous rating of 80 bhp at 1600 rpm.

GASOLINE. Der Schienen-Omnibus der Kleinbahn Lueneburg-Soltau, Mueller-Touraine and Kohlmeyer. Verkehrstechnik n 24a Sept 24 1932 p 529–32. Mechanical features and operating results of 38 passenger rail motor cars of Lueneburg-Soltau railroad equipped with Ford 4-cyl. engine.

Gasoline-Electric Cars, Canadian Pacific Railway. Can Ry and Mar World n 417 Nov 1932 p 553–5. Two gas-electric cars, placed in service recently between Winnipeg and Moose Jaw, Sask, by Canadian Pacific Ry; length over body 76 ft 2 in.; wheelbase 7 ft 10 in.; width over body 9 ft 9$^3/_8$ in.; height over all 16 ft 1 in.; power plant consists of 400 hp 8-cyl. Winton Engine, with cyl. 8-in. bore and 10-in. stroke; cars designed to haul trailer passenger car.

STEAM. New Southern Railway Rail-Bus. Ry Gaz v 57 n 16 Oct 14 1932 p 456–7. "Sentinel-Cammell" rail bus on Dyke branch of Southern Railway carries 44 passengers and has small luggage compartment; speed 60 mph; boiler of "Sentinel" standard vertical design, pressed to 325 lb per sq in. and fitted with patent automatic stoker and feedwater regulator, making bus as automatic as possible and enabling it to be worked by one man; elevation and plan diagram.

ROCKET PROPULSION

PROGRESS IN. Praktische Arbeit an der Fluessigkeitsrakete, W. Ley. Maschinenkonstrukteur-Betriebstechnik v 65 n 19–20 Oct 10 1932 p 118–22. Practical progress in rocket propulsion in Germany; propulsor weighing 2.75 kg empty reaches height of 750 m using $^1/_3$ liter gasoline and 1 liter liquid oxygen; duration of flight 40 sec

ROLLS

CAST IRON. Ein neuer Walzentyp fuer das Kaltwalzen von Metallen, F. Krau. Zeit fuer Metallkunde v 24 n 9 Sept 1932 p 226–8 and (discussion) 228–9. New type of roll for cold rolling of metals; critical roll hardness for rolling of aluminum, copper, nickel, iron, and brass; properties of electric-furnace-melted alloy chilled iron on martensite-cementite basis, as compared with unalloyed chilled iron.

SAND, FOUNDRY

TREATMENT. Mechanical Preparation and Handling of Sand in Non-Repetition Foundries, R. Macnab. Foundry Trade J v 47 n 844 Oct 20 1932 p 239–40 (discussion) 240 and 255. Extent to which methods employed in quantity-production foundries can be applied to less specialized branches of trade; replacing of human labor by machinery; types of sand-preparing machines; roller mixers; floor sand mixers, etc.; sand handling; new sand; sand for machine and hand work; facing sand; core sand. Before Inst. Brit. Foundrymen.

SHEET STEEL

DRAWING. Percent Elongation in Tensile Test as Method of Measuring Ductility of Thin Sheets, R. L. Kenyon. Metals and Alloys v 3 n 10 Oct 1932 p 220–5 and 232. Effect of testing speed on relationship between elongation observed on samples with 2- and 4-in. gage lengths; effect of proximity of shoulders to measured gage length upon observed percentage elongation; methods of measuring uniform elongation and reduction of area and effect of gage length; elongation correction factors for specimens of different thickness, but of equal length and width.

SHELLS

DRAWING. Herstellung komplizierter Zylinder aus Messing, A. Wiedenhoff. Maschinen Konstrukteur v 65 n 17–18 Sept 10 1932 (Werkzeug) p 107–8. Deep drawing of complicated cylindrical brass shells.

STEAM CONDENSERS

CORROSION. Anfressungen an Kondensatorrohren, N. Christmann. Waerme v 55 n 40 Oct 1 1932 p 689–91. Corrosion of condenser tubes; contribution to study of cause of corrosion of brass tubes based on laboratory investigations; defective tinning of inside of tube caused local formation of elements between tin and brass; injurious effect of cleaning tubes with hydrocyanic acid; means of avoiding and overcoming corrosive action.

LARGE. World's Largest Condensers at Hudson Avenue. Power Plant Eng v 36 n 19 Nov 1932 p 750–3. 101,000 sq ft units serve 160,000-kw units Nos. 7 and 8 at world's largest station; condenser surface 0.631 sq ft per kw; each unit requires 200,000 gpm condensing water; specifications; dimensions and auxiliaries.

STEAM PIPE LINES

HIGH-PRESSURE. Erecting High-Pressure, High-Temperature Steam Line at West Va. Pulp & Paper Co., H. C. Schramm. Heat Piping and Air Conditioning v 4 n 9 Sept 1932 p 598–601. 600-lb, 720-F steam line was arc welded, using shielded electrodes; number of practical helps worked out.

HIGH TEMPERATURES. Steam Pipe Work, J. A. Aiton. Engineer v 154 n 4007 Oct 28 1932 p 438–9. Contribution to problem of creep; question to be put to metallurgist is what stress will produce creep of $^1/_{10}$ of one-millionth of inch per inch per hour at 900 F. and on his answer depends design of piping; considerable care must be taken in manufacture of creased and corrugated pipes; all creased and corrugated bends must be annealed, and plain bends ought to be. Before Elec. Power Engrs.' Assn.

STEAM POWER PLANTS

ASH HANDLING. Flue Dust and Ash Handling Plant at Ironbridge Power Station. Steam Engr v 11 n 1 Oct 1932 p 7–10 and 13. Hydrojet ash-handling plant supplied by Ash Co., London, is operated at intervals according to boiler load, when whole of ash and clinker is discharged by high velocity sluicing system; ash is fed out at rate of 1 to 1$^1/_2$ tons per min into sluiceway running length of boiler house; longitudinal and end sections of ash-removal plant; sectional view through one of Stirling boilers.

AUSTRIA. Die neue 22 atue-Dampfkraftanlage des Kraftwerkes Engerthstrasse der Wiener staedt. Elektrizitaetswerke, F. Siedle. Elektrotechnik und Maschinenbau v 50 n 44 Oct 30 1932 p 602–5. New steam-generating equipment for 22 atm abs of Vienna Municipal power plant in Engerthstrasse; operating experience and tests on battery of 4 boilers generating 200,000 kg steam per hr; 2397 sq m heating surface supplying two turbines of 20,000 and 15,000 kw.

NATURAL-GAS. Natural Gas Fired Boilers for Railroad Power Plant, J. B. Nealey. Gas Age-Rec v 70 n 20 Nov 12 1932 p 511–12 and 529. Conversion of twelve 600-hp boilers, supplying steam to three 5000-kw turbo-generators in power house of Southern Pacific Railroad Co. at Fruitvale, Calif., to natural-gas firing; boiler furnaces, originally built for oil firing, were provided with more combustion space by removing boiler floor which was 3 ft above boiler-room floor, and laying new flooring of hollow tile and Sil-O-Cel brick on boiler-room floor, with draft through tile to reduce heat radiation.

STEAM TURBINES

DESIGN. Dampferzeuger mit Turbine, H. Vorkauf. VDI Zeit v 76 n 41 Oct 8 1932 p 988–90. Operating economies effected by combination of water-tube boiler and turbine rotor in one unit; improved heat transfer and elimination of heating equipment.

STEEL, HEAT TREATMENT OF

QUENCHING. Quench Cracks in Forgings, B. Thomas. Heat Treating and Forging v 18 n 10 Oct 1932 p 577–9. Principal sources of cracks, including forging defects, formation of scale, segregation; sudden changes in section and sharp corners; effect of composition, particularly manganese content.

REFINING GRAIN STRUCTURE. Influence of Hot Rolling and Forging Upon Structure of Steel Alloys, W. J. Merten. Heat Treating and Forging v 18 n 9 Sept 1932 p 525–8. Elimination of cold and hot shortness by control of crystal growth; treatment for thermal structural stability and maximum refinement of grain structures.

WELDS

STRESSES IN. Die Beanspruchung schraubenfoermiger Schweissnaehte an geschlossenen zylindrischen Gefaessen, W. Doerrscheidt. Waerme v 55 n 39 Sept 24 1932 p 661–3. Stress of spiral welded joints of closed cylindrical vessels; stress caused by internal pressure and expressed by formula of wall thickness; test to destruction of container with zigzag-shaped welded joint.

Spannungen beim Schweissen, E. Helfrich. Waerme v 55 n 39 Sept 24 1932 p 654–60. Stresses in welds; fundamental cause stated to be non-uniform heating of welded pieces; relation between temperature and stress and between expansion and stress; stress curves; means of reducing stresses in welds.